PSC REF#:204119

Public Service Commission of Wisconsin
RECEIVED: 05/07/14, 8:39:38 AM

Customer Demand Study

Prepared for the

Milwaukee Water Works

by Trilogy Consulting, LLC

April 2014

TRILOGY
CONSULTING, LLC
MUNICIPAL & UTILITY ADVISORS

TABLE OF CONTENTS

SECTION I: INTRODUCTION AND STUDY PURPOSE

INTRODUCTION

The Milwaukee Water Works is a publicly owned utility of the City of Milwaukee, providing safe drinking water to Milwaukee and residents and business in fifteen surrounding communities. The utility's retail service area includes customers in Milwaukee, Greenfield, Hales Corners, St. Francis, a portion of Franklin, and West Milwaukee. In addition, the utility serves Brown Deer, Butler, Greendale, Menomonee Falls, Mequon, Milwaukee County Grounds, New Berlin, Shorewood, Wauwatosa, and West Allis as wholesale customers. In total, Milwaukee Water Works serves a population of over 867,000, with over 162,000 retail customers, ten wholesale communities, and average water sales in excess of 83 million gallons per day (MGD).

Rates for service for each of Milwaukee's retail customer classes and for each wholesale customer are established by the Wisconsin Public Service Commission (PSC) based on the services provided and the demand characteristics of each customer class (residential, commercial, industrial, public authority retail customers and each of the wholesale communities). Important factors in determining the share of costs allocated to each class are the ratios of maximum day and maximum hour demand to average day demand that are used for each class. A small adjustment in the ratios can result in significant changes in the costs allocated to each class.

The demand factors used for Milwaukee's previous rate studies were developed in a 1977 study by Black and Veatch, based on hourly-metered water use data for several sample areas within the utility's service area. A study completed by Trilogy Consulting in 2013 based on data collected in 2012, indicated that these 1977 factors do not represent current patterns of water demand. This current study builds upon the 2013 study, augmenting it with additional data to measure current patterns of maximum day and maximum hour demand for each of Milwaukee's customer classes and to develop new demand factors for each class.

PURPOSE OF THE STUDY

The purpose of this study is to develop appropriate demand factors for each customer class to be used for the utility's cost of service studies, and establish a methodology for determining appropriate peaking factors going forward.

In order to determine the specific demand characteristics to measure, and therefore the appropriate study design and sampling methodology, it is important to understand how the demand factors are used in the cost of service study.

The PSC uses the base-extra capacity method for cost of service allocation. Under this method, a utility's revenue requirements are first allocated between the following categories:

- Base capacity to meet average daily water demands
- Extra capacity to meet maximum day demand
- Extra capacity to meet maximum hour demand
- Billing costs

- Meters and services
- Fire protection

Each of these categories of costs is then allocated between customer classes based on each class's proportionate share of the demand. For base costs, the share of demand is each class's share of average day demand. For maximum day and maximum hour costs, the amount of maximum day and maximum hour demands for each class are estimated by multiplying the average daily demand for the class by the ratio of maximum day to average day demand and the ratio of maximum hour to average day demand.

There are several important features about how these demand factors are determined and used that are important to note. First, the demand factor is intended to represent the expected maximum day or maximum hour demand ratio for the customer class *as a whole*, also referred to as the coincident peak. It is not intended to be the average of the ratios for the individual customers within the class. Since the purpose of the cost of service study is to allocate costs between customer classes, not between individual customers, the factor of interest is the coincident maximum demand of the class as a whole, not the non-coincident maximum demands of individual customers. The maximum demand ratio for the class as a whole will almost always be lower than the average ratios for the individual customers, because only some of the individual customers will have a maximum demand that coincides with, or occurs at the same time as, the period of time that the maximum demand of the class as a whole occurs.

A second important feature is that the demand factors are usually estimated rather than measured. Most utilities do not have the capability to measure the hourly or daily water demand for each customer class. Typically, demand factors are based on rules of thumb or industry standards. These industry standards may be adjusted based on the individual utility's system-wide demand patterns or available data for specific customers.

Finally, it is not necessary that the demand factors represent the highest ratio of maximum day demand to average day demand that could ever be expected for each customer class. The purpose of the cost of service study is to allocate a proportionate share of costs to each customer class based on a reasonable estimate of current demand from each class. Since demand fluctuates from year to year, maximum demand to average demand ratios are intended to represent typical or average conditions, rather than extreme conditions.

DEFINITIONS

Throughout this report, many terms will be used that are esoteric to statistical analysis and water utility cost-of-service rate-making. These are defined in this section:

Average Day – The average day of water usage during a specific period of time, normally one year, unless otherwise specified.

Billing Group – The group of customers that the Milwaukee Water Works bills during one weekly cycle. For example, residential customers are in 1 of 12 billing groups, each group being billed once per quarter in successive weeks.

Coincident Demand – The total water usage for all customers at any given moment; this can be used to describe all individual customer within a customer class or all customer classes within a water utility.

Consumption – The amount of water a customer or customer class uses; interchangeable with *Demand* and *Usage.*

Cost-of-Service – An analysis used to determine the costs to provide water service to customers of different classes (i.e. Residential, Commercial, Industrial, Public Authority, Wholesale, et al.).

Customer Class – A group of customers with certain shared characteristics that are grouped together into one classification.

Maximum Day – The single greatest day of water usage during a specific period of time, normally 1 year, unless otherwise specified; interchangeable with *Peak Day.*

Maximum Hour – The single greatest hour of water usage during a specific period of time, normally 1 year, unless otherwise specified; interchangeable with *Peak Hour.* For purposes of this study, hourly usage is multiplied by 24 in order to equate units to daily usage.

Maximum Month – The single greatest month of water usage during any one year.

Maximum Quarter – The single greatest quarter of water usage during any one year.

MD:AD – Ratio of Maximum Day water usage to Average Day water usage.

MH:AD – Ratio of Maximum Hour water usage to Average Day water usage.

MQ:AD – Ratio of the Average Day during the Maximum Quarter water usage to Average Day water usage.

Non-coincident Demand – The sum of all customers' or customer classes' water usage without respect to the time of its occurrence; computed using Maximum Day or Maximum Hour water usage.

Peaking Factor – A ratio used in a water utility cost-of-service study that is used to allocate Maximum Day and Maximum Hour costs to customer classes.

Population – The total group of people or things from which a sample is taken for measurement; for this study, the population is all customers served by the Milwaukee Water Works.

Pumpage – The amount water that is pumped by the utility to serve its customers; this differs from consumption because some water that is pumped is not sold to or used by customers (e.g. fighting fires, utility operations).

Sample – A subset of a population that is measured for certain variables and is representative of the total population.

Wholesale Customer – A customer (usually another municipal water utility) of a water utility that purchases water from the utility but owns its own distribution system to supply to its own customers.

SECTION II: METHODOLOGY

Ideally, the maximum day and maximum hour demands for each customer class would be determined based on several years' worth of hourly measurements of total demand for each customer class. However, Milwaukee Water Works retail customers, and two of its wholesale customers, generally do not have water meters that read and store hourly consumption data.

In 2012, meters were installed that were capable of reading and storing hourly consumption data on a sample of customers in each retail customer class. These meters were used again to collect additional data to be analyzed during 2013, with some additional meters installed where possible and advantageous to the accuracy of the analysis. The critical questions for determining sampling methodology for retail customers included:

- How many customers from each customer class are needed to provide an adequate sample size;
- How should the sample customers be selected; and
- What is the appropriate time period for which to gather the hourly meter reading data?

Based on the purposes for which the data will be used, it was important that the sample size and composition be selected so that the demand patterns of the sample *as a whole* were as close as possible to the demand patterns of the entire class *as a whole*.

For most statistical analyses, the objective is to select a sample with a mix of individuals with similar characteristics as compared to the mix of individuals in the population. This is done by selecting a large enough random sample that the mean of the measured variable is within a certain confidence interval of the mean of the population as a whole. Thus, the sample size is determined based on the size of the population and the estimated standard deviation of the measured statistic. This is the approach that was used in the Black & Veatch study that determined the demand factors currently used for Milwaukee Water Works' retail customers.

A traditional approach to statistical analysis like this is not useful for this study for several reasons:

- As explained above, the peaking ratios of individual customers within each customer class is not the variable of interest.
- The purpose is to obtain a sample with coincident (sum total) ratios of maximum day and maximum hour usage that approximate the coincident peaking ratio of the population as a whole.
- For some customer classes, there may be relatively few customers with large water usage that drive the peaks of the class as a whole. If a random sample is selected, or even if the sample includes customers representing a variety of sizes and usage patterns, the selected sample may exclude the customers that determine the patterns of the class as a whole.

The measured variables of interest in this study are not the maximum day demand or maximum hour demand of any of the individual customers. The variables of interest are the highest total daily demand and highest total hour demand of the total of all of the customers in the sample for each customer class. These variables are determined by summing the hourly demand and the daily demand of all of the

sampled customers from a particular class and finding the one maximum value during the sample period. The challenge, therefore, was to find the right mix of sample customers whose highest day demand compared to its average day demand, as a group, is similar to the highest day demand to average day demand of the entire customer class.

SECTION III: HISTORICAL ANALYSIS OF RETAIL CUSTOMERS

In order to determine the appropriate sample size and composition, it was important to understand the historical consumption patterns of the individual customer classes and the total water pumpage of the utility. Although the data was only available on a monthly or quarterly basis for retail customers, the analysis of historical consumption patterns revealed important characteristics about each of the customer classes, as described below.

RESIDENTIAL

For the residential class, the focus of the historical data analysis was to: 1) confirm the best time of year for sampling, based on the peak quarter of water demand from year to year; and 2) examine the general peak day to average day ratio for the class based on the quarterly water usage data.

The utility initially provided the following data regarding its retail residential customers:

- Metered water consumption by quarter for each of its 12 retail residential billing groups for the period 2007 – 2011, which were further classified into 3 main billing groups based on geography and time of meter reading, with 4 subgroups within each group
- A list of its 82 retail residential meter reading routes, the months of the year during which each of the routes are billed, the number of customer accounts in each route, and a map showing the boundaries of each route

The meter reading routes vary in geographic size and number of customers, with a minimum of 7 residential accounts per route and a maximum of 3,023 accounts per route. Of the 82 routes, 11 routes have fewer than 1,000 residential accounts, 40 have 1,000 to 1,999 accounts, 30 have 2,000 to 2,999 accounts and only 1 has more than 3,000 accounts. The average number of residential accounts per route is 1,726, and the median is 1,826 accounts.

The metered water consumption by quarter was analyzed to determine the following for each of the twelve billing groups for each year during the period 2007-2011, as shown in Table 1:

- Peak quarterly consumption by year
- Average daily consumption during the peak quarter
- Average daily consumption for the year
- The ratio of average daily consumption during the peak quarter to the average daily consumption for the year

The ratio of peak quarterly consumption to average consumption ranged from a low of 1.026 to a high of 1.271. Statistical analysis, based on the 5-year sample, indicated a high probability that the individual billing groups have significantly different quarterly peaking characteristics.

The peak-to-average quarter ratios for the various billing groups were referenced to the meter reading route map to determine if there were any discernible patterns in peaking ratios relative to location. It was found that the subgroups in Billing Group 1, which have relatively low quarterly peak-to-average demand ratios, are primarily located in the central portion of the City of Milwaukee and include retail customers in the Village of West Milwaukee. Billing Group 2 subgroups, which have generally higher

peak-to-average quarter ratios, consist primarily of areas on the south side of Milwaukee and the suburban retail customers of Greenfield, Hales Corners and St. Francis. Billing Group 3 subgroups, which include the north central, north and northwest portions of Milwaukee, had varied peaking ratios.

A very broad conclusion that can be drawn from these patterns is that it appears that older, more densely developed areas may be expected to have lower ratios of peak-to-average consumption. Routes primarily consisting of the older, more densely developed areas generally exhibited lower ratios during the past five years; the newer, more suburban-style development experienced higher ratios. The north and northwest areas of the City, which contain a mix of development patterns, had a mix of peak-to-average ratios.

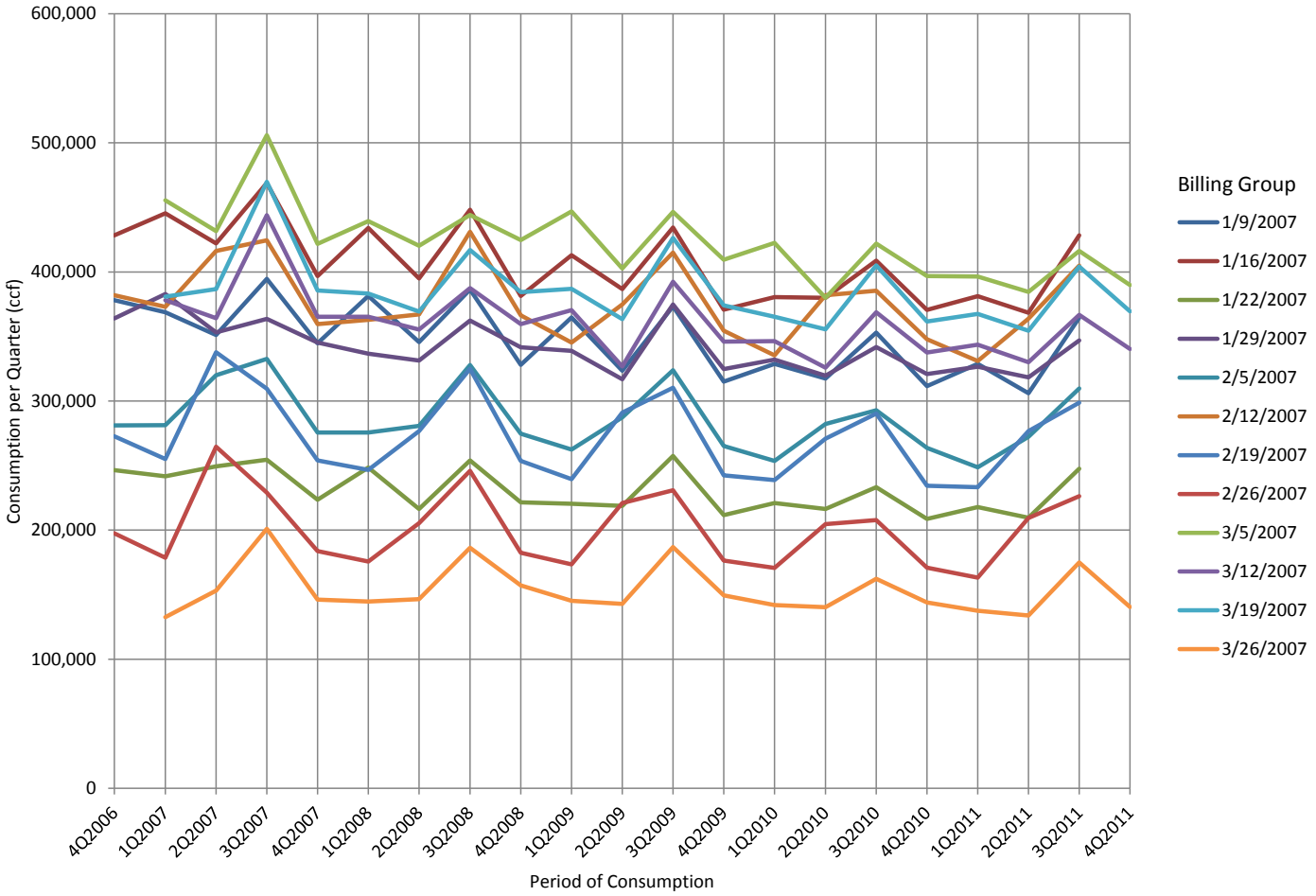
Chart 1 shows the pattern of retail residential water consumption for the period 2007-2011. The utility bills one of its 12 residential billing groups each week, so the metering period for each billing group is different. Therefore, it is not possible to sum the total consumption of all retail residential customers over the same period with any meaningful results. To show the total amount of consumption per quarter for Chart 1, the consumption for each of the twelve billing groups was assigned to the nearest quarter. Consumption billed during the eight weeks of the first quarter of the year was assumed to be consumption that occurred primarily during the fourth quarter of the prior year. The majority of the consumption billed during the last four weeks of the first quarter of the year was assumed to have occurred primarily during the first quarter of the year.

This graph reveals several important characteristics of the pattern of residential water consumption. First, all of the billing groups typically experience the peak quarter of consumption in the third quarter of the year (July, August and September consumption), with some secondary peaks occurring in the first quarter of the year. For ten of the twelve billing groups, the highest quarterly water consumption occurred during 2007. The general trend for all billing groups has been a slight decline in overall, average and peak consumption since 2007.

Table 1 - Analysis of Retail Residential Water Consumption

	2007	2008	2009	2010	2011	Average
Billing Group 1 - Billed January, April, July, & October						
A. Billed 1/9/2007						
Average Day in Peak Quarter (ccf)	4,324	4,234	4,090	3,868	3,995	
Average Day for Year (ccf)	4,089	3,995	3,807	3,600	3,591	
Average Day-Peak Quarter/Average Day-Year	1.057	1.060	1.074	1.074	1.113	1.076
B. Billed 1/16/2007						
Average Day in Peak Quarter (ccf)	5,139	4,911	4,760	4,478	4,693	
Average Day for Year (ccf)	4,835	4,586	4,426	4,219	4,242	
Average Day-Peak Quarter/Average Day-Year	1.063	1.071	1.075	1.061	1.106	1.075
C. Billed 1/22/2007						
Average Day in Peak Quarter (ccf)	2,789	2,782	2,822	2,556	2,714	
Average Day for Year (ccf)	2,718	2,582	2,516	2,417	2,421	
Average Day-Peak Quarter/Average Day-Year	1.026	1.077	1.122	1.058	1.121	1.081
D. Billed 1/29/2007						
Average Day in Peak Quarter (ccf)	4,195	3,971	4,107	3,745	3,802	
Average Day for Year (ccf)	4,010	3,769	3,759	3,611	3,596	
Average Day-Peak Quarter/Average Day-Year	1.046	1.054	1.093	1.037	1.057	1.057
Billing Group 2 - Billed February, May, August, & November						
A. Billed 2/5/2007						
Average Day in Peak Quarter (ccf)	3,646	3,594	3,549	3,209	3,394	
Average Day for Year (ccf)	3,329	3,177	3,146	2,997	2,998	
Average Day-Peak Quarter/Average Day-Year	1.095	1.131	1.128	1.071	1.132	1.111
B. Billed 2/12/2007						
Average Day in Peak Quarter (ccf)	4,652	4,724	4,547	4,225	4,436	
Average Day for Year (ccf)	4,372	4,166	4,113	3,993	3,966	
Average Day-Peak Quarter/Average Day-Year	1.064	1.134	1.106	1.058	1.119	1.096
C. Billed 2/19/2007						
Average Day in Peak Quarter (ccf)	3,701	3,560	3,399	3,180	3,273	
Average Day for Year (ccf)	3,219	3,019	2,999	2,855	2,857	
Average Day-Peak Quarter/Average Day-Year	1.150	1.179	1.133	1.114	1.146	1.144
D. Billed 2/26/2007						
Average Day in Peak Quarter (ccf)	2,900	2,695	2,531	2,276	2,480	
Average Day for Year (ccf)	2,383	2,221	2,213	2,081	2,109	
Average Day-Peak Quarter/Average Day-Year	1.217	1.213	1.144	1.094	1.176	1.169
Billing Group 3 - Billed March, June, September & December						
A. Billed 3/5/2007						
Average Day in Peak Quarter (ccf)	5,544	4,868	4,896	4,630	4,562	
Average Day for Year (ccf)	4,972	4,736	4,672	4,442	4,349	
Average Day-Peak Quarter/Average Day-Year	1.115	1.028	1.048	1.042	1.049	1.056
B. Billed 3/12/2007						
Average Day in Peak Quarter (ccf)	4,864	4,246	4,300	4,041	4,019	
Average Day for Year (ccf)	4,250	4,021	3,933	3,777	3,783	
Average Day-Peak Quarter/Average Day-Year	1.144	1.056	1.093	1.070	1.062	1.085
C. Billed 3/19/2007						
Average Day in Peak Quarter (ccf)	5,147	4,570	4,672	4,439	4,429	
Average Day for Year (ccf)	4,446	4,258	4,249	4,075	4,097	
Average Day-Peak Quarter/Average Day-Year	1.158	1.073	1.100	1.089	1.081	1.100
D. Billed 3/26/2007						
Average Day in Peak Quarter (ccf)	2,202	2,042	2,047	1,778	1,917	
Average Day for Year (ccf)	1,733	1,739	1,710	1,612	1,608	
Average Day-Peak Quarter/Average Day-Year	1.271	1.174	1.197	1.103	1.192	1.187
Mean: Average Day-Peak Quarter/Average Day-Year	1.120	1.112	1.112	1.074	1.122	1.108
Wghtd. Mean: Average Day-Peak Quarter/Average Day-Year	1.107	1.093	1.101	1.069	1.103	1.095
Std. Dev.: Average Day-Peak Quarter/Average Day-Year	0.068	0.059	0.039	0.023	0.045	

Chart 1 - Residential Water Consumption by Quarter and Billing Group, 2007-2011



NON-RESIDENTIAL

The nonresidential classes were expected to exhibit less variability in consumption per quarter but probably less regularity in annual consumption patterns. In other words, the ratio of the peak quarter to average quarter may be less for the nonresidential classes, but the peak quarter may not occur in the same quarter every year as would be expected for the residential class. In addition, a higher percentage of water consumption for the nonresidential customer classes is concentrated in relatively few customer accounts. Therefore, in addition to the goals identified for the analysis of residential customer data, the analysis of nonresidential customer data was also used to: 1) identify those customers that cause the water consumption patterns of that class and/or could be considered a separate customer class; and 2) refine the sampling methodology, the adequacy of the number of samples and the appropriate mix of the customers in each class to sample.

The utility initially provided the following data regarding its retail non-residential customers:

- The account number, address, customer classification and billed water consumption for each nonresidential customer for each billing period during the period 2007 – 2011

In each of the nonresidential customer classes (Commercial, Industrial and Public Authority), some of the customers are billed monthly while the majority of customers are billed quarterly. Throughout the utility's history, it selected the customer accounts to bill monthly based on the presence of a high amount of water consumption, although with changes in water consumption over time, some of the monthly billing customers are no longer among those with the highest consumption. As with the residential customers, the utility bills some customers each week, so the customers on a monthly billing frequency are divided into 5 billing groups and customers billed on a quarterly frequency are divided into 12 billing groups.

The number of customers with billed water consumption each year is shown in Table 2, by customer class and billing frequency. As shown, customers billed on a monthly frequency represent the minority of the customers in each class; however, their consumption makes up a larger proportion of the billed consumption. This pattern is most pronounced for industrial customers, where the customers billed on a monthly frequency account for 25 to 28 percent of the industrial customers but 88 to 91 percent of the total consumption.

The billed water consumption was analyzed for each customer class by customers billed quarterly, those billed monthly, and those billed monthly that are among the largest nonresidential customers served by the utility to determine the following characteristics during the period 2007-2011, as shown in Tables 3-8:

- Peak quarterly or monthly consumption by year
- Average daily consumption during the peak quarter or month
- Average daily consumption for the year
- The ratio of daily consumption during the peak quarter or month to the average daily consumption for the year

Table 2 - Summary of Nonresidential Customer Accounts and Consumption, 2007-2011

	2007		2008		2009		2010		2011		Average: 2007-2011			
	No. Cust.	Annual Consumpt. (ccf)	No. Cust.	Annual Consumpt. (ccf)	No. Cust.	Annual Consumpt. (ccf)	No. Cust.	Annual Consumpt. (ccf)	No. Cust.	Annual Consumpt. (ccf)	No. Cust.	Percent	Annual Consumpt. (ccf)	Percent
Commercial Customers														
Monthly	454	3,165,904	460	3,153,357	466	2,963,398	471	3,000,533	476	2,826,843	465	3%	3,022,007	28%
Quarterly	13,320	8,252,401	13,291	8,055,899	13,218	7,881,689	13,144	7,658,517	13,042	7,608,100	13,203	97%	7,891,321	72%
Total	13,774	11,418,305	13,750	11,209,256	13,684	10,845,087	13,615	10,659,050	13,518	10,434,943	13,668	100%	10,913,328	100%
Industrial Customers														
Monthly	320	5,215,419	313	4,977,680	307	4,681,848	310	4,795,159	313	4,582,791	312	27%	4,850,579	89%
Quarterly	880	697,101	867	637,716	848	548,497	832	584,281	816	450,113	849	73%	583,542	11%
Total	1,200	5,912,520	1,180	5,615,396	1,155	5,230,345	1,142	5,379,440	1,129	5,032,904	1,161	100%	5,434,121	100%
Public Authority Customers														
Monthly	72	1,116,876	71	1,240,813	71	1,224,386	70	1,253,619	72	1,231,777	71	14%	1,213,494	48%
Quarterly	462	1,282,028	439	1,281,054	438	1,349,189	435	1,266,373	440	1,267,772	443	86%	1,289,283	52%
Total	534	2,398,904	510	2,521,867	509	2,573,575	506	2,519,992	512	2,499,549	514	100%	2,502,777	100%

The largest customer accounts were identified as those with total billed consumption over the period 2007 to 2011 at or above the 99.4 percentile. Within this group of largest customers were 109 customer accounts with total billed consumption from 2007 to 2011 at or above 95,784 CCF per account. In addition, in order to include an adequate number of public authority customers, the next largest 12 public authority customers were included in the analysis of the largest customers. These 121 customers accounted for 39.6 percent of all nonresidential retail consumption between 2007 and 2011. The maximum total billed consumption for a single customer account over that period was 2.8 million CCF (hundred cubic feet).

Commercial

The utility had approximately 13,500 commercial customers with some consumption in 2011. This class is the second largest customer class accounting for almost ten percent of retail customers and thirty-one percent of retail consumption. The 476 customers billed on a monthly basis accounted for approximately 27 percent of commercial consumption in 2011, while the 13,042 customers billed quarterly accounted for 73 percent.

For those commercial customers billed on a monthly frequency, the ratio of peak month to average consumption by year ranged from 1.297 to 1.440 (Table 3). Those monthly billed costumers that are among the largest served, which represent less than half of the consumption of this group, had consistently higher ratios of peak monthly consumption as compared to the remaining customers within this group and the customer class as a whole.

Table 3 - Commercial Customers Average and Peak Monthly Consumption, 2007-2011

	2007	2008	2009	2010	2011	Average
Commercial - Monthly (Total Class)						
Average Day in Peak Month	11,819	12,030	10,527	11,835	10,244	
Average Day for Year	8,674	8,616	8,119	8,221	7,745	
Average Day-Peak Month/Average Day-Year	1.363	1.396	1.297	1.440	1.323	1.364
Commercial - Monthly (Largest Users)						
Average Day in Peak Month	5,016	5,179	4,637	5,267	4,470	
Average Day for Year	3,533	3,629	3,495	3,465	3,090	
Average Day-Peak Month/Average Day-Year	1.420	1.427	1.327	1.520	1.447	1.428
Commercial - Monthly (All Other Users)						
Average Day in Peak Month	6,803	6,874	5,890	6,567	6,062	
Average Day for Year	5,141	4,987	4,624	4,756	4,655	
Average Day-Peak Month/Average Day-Year	1.323	1.378	1.274	1.381	1.302	1.332

Note: Usage is in hundred cubic feet (CCF).

Table 4 - Commercial Customers Average and Peak Quarterly Consumption, 2007-2011

	2007	2008	2009	2010	2011	Average
Commercial - Quarterly - 1/9/07 (Total Class)						
Average Day in Peak Quarter	3,685	3,713	3,513	3,673	3,643	
Average Day for Year	3,398	3,310	3,262	3,231	3,285	
Average Day-Peak Quarter/Average Day-Year	1.084	1.122	1.077	1.137	1.109	1.106
Commercial - Quarterly - 1/16/07 (Total Class)						
Average Day in Peak Quarter	623	615	660	577	564	
Average Day for Year	587	563	577	539	519	
Average Day-Peak Quarter/Average Day-Year	1.061	1.092	1.144	1.071	1.087	1.091
Commercial - Quarterly - 1/22/07 (Total Class)						
Average Day in Peak Quarter	1,742	1,576	1,503	1,494	1,543	
Average Day for Year	1,708	1,491	1,457	1,423	1,447	
Average Day-Peak Quarter/Average Day-Year	1.020	1.057	1.031	1.049	1.066	1.045
Commercial - Quarterly - 1/29/07 (Total Class)						
Average Day in Peak Quarter	3,456	3,644	3,547	3,110	3,268	
Average Day for Year	3,115	3,107	3,095	2,877	3,014	
Average Day-Peak Quarter/Average Day-Year	1.109	1.173	1.146	1.081	1.084	1.119
Commercial - Quarterly - 1/31/07 (Total Class)						
Average Day in Peak Quarter	295	290	307	287	293	
Average Day for Year	287	277	281	269	277	
Average Day-Peak Quarter/Average Day-Year	1.030	1.047	1.093	1.067	1.056	1.059
Commercial - Quarterly - 2/5/07 (Total Class)						
Average Day in Peak Quarter	947	897	833	840	845	
Average Day for Year	893	849	800	785	784	
Average Day-Peak Quarter/Average Day-Year	1.060	1.057	1.041	1.070	1.077	1.061
Commercial - Quarterly - 2/12/07 (Total Class)						
Average Day in Peak Quarter	914	920	836	843	856	
Average Day for Year	866	840	799	806	799	
Average Day-Peak Quarter/Average Day-Year	1.056	1.095	1.045	1.047	1.071	1.063
Commercial - Quarterly - 2/19/07 (Total Class)						
Average Day in Peak Quarter	1,347	1,320	1,288	1,310	1,244	
Average Day for Year	1,277	1,222	1,205	1,190	1,155	
Average Day-Peak Quarter/Average Day-Year	1.055	1.080	1.069	1.101	1.077	1.076
Commercial - Quarterly - 2/26/07 (Total Class)						
Average Day in Peak Quarter	3,334	3,203	3,101	3,210	3,053	
Average Day for Year	3,000	2,927	2,879	2,865	2,883	
Average Day-Peak Quarter/Average Day-Year	1.111	1.094	1.077	1.121	1.059	1.092
Commercial - Quarterly - 2/28/07 (Total Class)						
Average Day in Peak Quarter	174	167	143	134	143	
Average Day for Year	159	151	137	124	122	
Average Day-Peak Quarter/Average Day-Year	1.094	1.103	1.040	1.079	1.169	1.097
Commercial - Quarterly - 3/5/07 (Total Class)						
Average Day in Peak Quarter	898	891	957	872	765	
Average Day for Year	860	850	859	852	752	
Average Day-Peak Quarter/Average Day-Year	1.044	1.048	1.114	1.023	1.017	1.049
Commercial - Quarterly - 3/12/07 (Total Class)						
Average Day in Peak Quarter	966	903	887	829	797	
Average Day for Year	929	878	847	807	779	
Average Day-Peak Quarter/Average Day-Year	1.040	1.029	1.047	1.027	1.024	1.033
Commercial - Quarterly - 3/19/07 (Total Class)						
Average Day in Peak Quarter	1,702	1,757	1,665	1,685	1,533	
Average Day for Year	1,669	1,677	1,615	1,579	1,506	
Average Day-Peak Quarter/Average Day-Year	1.020	1.048	1.030	1.067	1.018	1.037
Commercial - Quarterly - 3/26/07 (Total Class)						
Average Day in Peak Quarter	3,636	3,610	3,546	3,301	3,241	
Average Day for Year	3,225	3,244	3,189	3,079	3,036	
Average Day-Peak Quarter/Average Day-Year	1.127	1.113	1.112	1.072	1.068	1.098
Commercial - Quarterly - 3/29/07 (Total Class)						
Average Day in Peak Quarter	739	651	645	606	532	
Average Day for Year	636	625	591	555	484	
Average Day-Peak Quarter/Average Day-Year	1.161	1.042	1.090	1.091	1.098	1.097
Commercial - Monthly (Total Class)						
Average Day in Peak Quarter	**11,250**	**11,195**	**10,198**	**10,933**	**9,845**	
Average Day for Year	**8,674**	**8,616**	**8,119**	**8,221**	**7,745**	
Average Day-Peak Quarter/Average Day-Year	**1.297**	**1.299**	**1.256**	**1.330**	**1.271**	**1.291**

Note: Usage is in hundred cubic feet (CCF).

Table 4 shows the analysis of peak quarter to average consumption for the commercial customers billed on a quarterly frequency, by billing group. The five-year average of the ratio of peak quarter to average consumption ranged from a low of 1.033 to a high of 1.119. Table 4 also shows the ratios of peak quarter to average consumption for the commercial customers billed on a monthly frequency, in an effort to compare monthly-billed customers to quarterly-billed customers using similar periods of consumption. The average peak quarter ratio for this group was 1.291 during the period 2007-2011, higher than those customers billed quarterly.

From this data, it appears that the larger customers in the commercial class tend to exhibit higher peak-to-average consumption ratios. Customers billed monthly, who are generally the largest customers within the entire commercial class, appear to exhibit higher ratios than those billed quarterly. When isolating only the group of customers billed monthly, those that are among the largest customers have higher peak ratios than the remainder of the group. This indicates that the largest commercial users do not consume water steadily throughout the year, but are seasonal in nature, more so than the smaller commercial customers. This is somewhat contradictory to traditional assumptions regarding large non-residential water consumers. It indicates that Milwaukee's largest individual commercial water customers are not users that are operational year-round, such as office buildings, but those with seasonal peaks, such as commercial recreational facilities.

While it is difficult to determine the comparative peak ratios for the class as a whole, given the data limitations discussed, a rough estimate was calculated that showed that the peak ratio for the entire commercial class during the period 2007-2011 was 1.141. The analysis concludes that there is not one particular group of customers that impacts the overall customer class peak ratio more than any other; it is the composite of all customers within the commercial class that determines the peak ratio of the class.

Industrial

The utility had approximately 1,100 industrial customers with some consumption in 2011. This class accounts for less than one percent of retail customers but nearly sixteen percent of retail consumption. The 313 customers billed monthly accounted for 91 percent of consumption in 2011, while the 816 customers billed quarterly only accounted for 9 percent.

For those industrial customers billed on a monthly frequency, the ratio of peak month to average consumption by year ranged from 1.137 to 1.213 (Table 5). Those monthly billed costumers that are among the largest served, which represent about 85 percent of the consumption of this group, had peak monthly to average consumption ratios that are similar to those of the group as a whole. The remaining customers in this group had significantly higher peak month to average consumption ratios as compared to the larger customers. This indicates that the remaining customers in this group did not have a great impact on the peak ratios; they were largely determined by the peaking characteristics of those largest customers.

Table 5 - Industrial Customers Average and Peak Monthly Consumption, 2007-2011

	2007	2008	2009	2010	2011	Average
Industrial - Monthly (Total Class)						
Peak Month	505,434	471,588	476,375	469,805	460,387	
Average Day in Peak Month	16,572	15,462	15,619	15,403	15,095	
Average Day for Year	14,289	13,600	12,827	13,137	12,556	
Average Day-Peak Month/Average Day-Year	1.160	1.137	1.218	1.172	1.202	1.178
Industrial - Monthly (Largest Users)						
Peak Month	418,622	402,453	412,045	403,642	394,647	
Average Day in Peak Month	13,725	13,195	13,510	13,234	12,939	
Average Day for Year	12,146	11,671	11,261	11,641	10,785	
Average Day-Peak Month/Average Day-Year	1.130	1.131	1.200	1.137	1.200	1.159
Industrial - Monthly (All Other Users)						
Peak Month	97,044	75,946	64,330	66,163	78,697	
Average Day in Peak Month	3,182	2,490	2,109	2,169	2,580	
Average Day for Year	2,143	1,929	1,566	1,496	1,771	
Average Day-Peak Month/Average Day-Year	1.485	1.291	1.347	1.450	1.457	1.406

Note: Usage is in hundred cubic feet (CCF).

Table 6 shows the analysis of peak quarter to average consumption for the industrial customers billed on a quarterly frequency, by billing group. The five-year average of the ratio of peak quarter to average consumption ranged from a low of 1.101 to a high of 1.329. However, many of these billing groups had a fairly small amount of usage within them, meaning that they would have little impact on the peak ratio of the industrial class as a whole. An attempt to show the composite peak ratio of all industrial customers billed quarterly was made, with the rough estimate calculated to be 1.238 during the period 2007-2011. Table 6 also shows the ratios of peak quarter to average consumption for the industrial customers billed on a monthly frequency, like the analysis for commercial customers. The average peak quarter ratio for this group was 1.111 during the period 2007-2011. Like the analysis of commercial customers, a rough estimate was calculated that showed that the peak ratio for the entire industrial class during the period 2007-2011 was 1.125. The analysis concludes that the peak ratio for the industrial customer class is largely determined by those customers billed monthly, and, within that subset group, the very largest customers that are billed monthly. Not coincidentally, these larger customers also make up the majority of the consumption for this class.

Table 6 - Industrial Customers Average and Peak Quarterly Consumption, 2007-2011

	2007	2008	2009	2010	2011	Average
Industrial - Quarterly - 1/9/07 (Total Class)						
Average Day in Peak Quarter	181	224	168	163	126	
Average Day for Year	149	168	147	120	105	
Average Day-Peak Quarter/Average Day-Year	1.214	1.332	1.142	1.362	1.198	1.250
Industrial - Quarterly - 1/16/07 (Total Class)						
Average Day in Peak Quarter	12	14	15	14	28	
Average Day for Year	12	12	13	12	21	
Average Day-Peak Quarter/Average Day-Year	1.063	1.103	1.172	1.117	1.343	1.160
Industrial - Quarterly - 1/22/07 (Total Class)						
Average Day in Peak Quarter	79	87	77	52	57	
Average Day for Year	78	82	61	46	55	
Average Day-Peak Quarter/Average Day-Year	1.018	1.061	1.267	1.121	1.039	1.101
Industrial - Quarterly - 1/29/07 (Total Class)						
Average Day in Peak Quarter	383	361	371	296	291	
Average Day for Year	345	308	315	278	257	
Average Day-Peak Quarter/Average Day-Year	1.108	1.173	1.175	1.063	1.131	1.130
Industrial - Quarterly - 2/5/07 (Total Class)						
Average Day in Peak Quarter	179	160	126	158	152	
Average Day for Year	158	134	105	140	141	
Average Day-Peak Quarter/Average Day-Year	1.131	1.190	1.203	1.128	1.083	1.147
Industrial - Quarterly - 2/12/07 (Total Class)						
Average Day in Peak Quarter	28	26	26	23	23	
Average Day for Year	25	23	22	21	20	
Average Day-Peak Quarter/Average Day-Year	1.116	1.130	1.178	1.093	1.184	1.140
Industrial - Quarterly - 2/19/07 (Total Class)						
Average Day in Peak Quarter	36	38	21	14	31	
Average Day for Year	30	36	17	14	19	
Average Day-Peak Quarter/Average Day-Year	1.203	1.076	1.240	1.043	1.669	1.246
Industrial - Quarterly - 2/26/07 (Total Class)						
Average Day in Peak Quarter	170	152	115	116	111	
Average Day for Year	151	131	97	93	101	
Average Day-Peak Quarter/Average Day-Year	1.128	1.161	1.181	1.250	1.100	1.164
Industrial - Quarterly - 3/5/07 (Total Class)						
Average Day in Peak Quarter	79	78	102	90	67	
Average Day for Year	75	73	70	73	63	
Average Day-Peak Quarter/Average Day-Year	1.063	1.069	1.454	1.231	1.063	1.176
Industrial - Quarterly - 3/12/07 (Total Class)						
Average Day in Peak Quarter	39	81	35	30	33	
Average Day for Year	33	40	31	27	27	
Average Day-Peak Quarter/Average Day-Year	1.157	2.013	1.129	1.102	1.242	1.329
Industrial - Quarterly - 3/19/07 (Total Class)						
Average Day in Peak Quarter	46	47	38	42	52	
Average Day for Year	40	41	35	34	41	
Average Day-Peak Quarter/Average Day-Year	1.159	1.124	1.065	1.245	1.270	1.172
Industrial - Quarterly - 3/26/07 (Total Class)						
Average Day in Peak Quarter	938	777	686	1,460	461	
Average Day for Year	815	693	589	744	383	
Average Day-Peak Quarter/Average Day-Year	1.151	1.121	1.165	1.963	1.203	1.321
Industrial - Monthly (Total Class)						
Average Day in Peak Quarter	**15,705**	**14,922**	**14,379**	**14,659**	**14,078**	
Average Day for Year	**14,289**	**13,600**	**12,827**	**13,137**	**12,556**	
Average Day-Peak Quarter/Average Day-Year	**1.099**	**1.097**	**1.121**	**1.116**	**1.121**	**1.111**

Note: Usage is in hundred cubic feet (CCF).

Public Authority

The utility had approximately 500 public authority customers with consumption in 2011. This class accounts for less than half of one percent of retail customers but nearly nine percent of retail consumption. The 72 customers billed monthly accounted for 49 percent of class consumption in 2011, while the 440 quarterly billed customers accounted for 51 percent.

For those public authority customers billed on a monthly frequency, the ratio of peak month to average consumption by year ranged from 1.137 to 1.399, with an average of 1.253 (Table 7). Those monthly billed costumers that are among the largest served, which represent about 90 percent of the consumption of this group, had peak monthly to average consumption ratios that are similar to those of the group as a whole. The remaining customers in this group varied between higher and lower peak month to average consumption ratios as compared to the larger customers.

Table 8 shows the analysis of peak quarter to average consumption for the public authority customers billed on a quarterly frequency, by billing group. The five-year average of the ratio of peak quarter to average consumption ranged from a low of 1.121 to a high of 3.279. The billing groups exhibiting high peak quarter ratios were those with very small consumption, meaning that those groups of customers would not have a great impact on the peak ratio of the public authority class as a whole. An attempt to show the composite peak ratio of all public authority customers billed quarterly was made, with the rough estimate calculated to be 1.283 during the period 2007-2011. Table 8 also shows the ratios of peak quarter to average consumption for the public authority customers billed on a monthly frequency, like the analysis performed for commercial and industrial customers. The average peak quarter ratio for this group was 1.158 during the period 2007-2011.

Table 7 - Public Authority Customers Average and Peak Monthly Consumption, 2007-2011

Public Authority - Monthly (Total Class)						
Peak Month	119,507	125,797	126,108	119,153	144,007	
Average Day in Peak Month	3,918	4,124	4,135	3,907	4,722	
Average Day for Year	3,060	3,390	3,354	3,435	3,375	
Average Day-Peak Month/Average Day-Year	1.281	1.217	1.233	1.137	1.399	1.253
Public Authority - Monthly (Largest Users)						
Peak Month	106,365	112,621	113,685	107,661	132,903	
Average Day in Peak Month	3,487	3,692	3,727	3,530	4,357	
Average Day for Year	2,679	3,002	2,955	3,048	2,858	
Average Day-Peak Month/Average Day-Year	1.302	1.230	1.261	1.158	1.525	1.295
Public Authority - Monthly (All Other Users)						
Peak Month	13,142	14,394	13,900	14,516	41,643	
Average Day in Peak Month	431	472	456	476	1,365	
Average Day for Year	381	388	399	386	517	
Average Day-Peak Month/Average Day-Year	1.131	1.215	1.141	1.233	2.642	1.472

Note: Usage is in hundred cubic feet (CCF).

Table 8 - Public Authority Customers Average and Peak Quarterly Consumption, 2007-2011

	2007	2008	2009	2010	2011	Average
Public Authority - Quarterly - 1/9/07 (Total Class)						
Average Day in Peak Quarter	20	31	28	25	22	
Average Day for Year	10	12	11	9	9	
Average Day-Peak Quarter/Average Day-Year	2.123	2.657	2.502	2.803	2.375	2.492
Public Authority - Quarterly - 1/16/07 (Total Class)						
Average Day in Peak Quarter	16	16	12	17	15	
Average Day for Year	7	6	5	6	6	
Average Day-Peak Quarter/Average Day-Year	2.302	2.582	2.559	2.883	2.644	2.594
Public Authority - Quarterly - 1/22/07 (Total Class)						
Average Day in Peak Quarter	10	8	9	7	7	
Average Day for Year	8	8	8	6	6	
Average Day-Peak Quarter/Average Day-Year	1.190	1.038	1.131	1.116	1.127	1.121
Public Authority - Quarterly - 1/29/07 (Total Class)						
Average Day in Peak Quarter	695	1,496	979	770	679	
Average Day for Year	481	653	655	549	227	
Average Day-Peak Quarter/Average Day-Year	1.443	2.293	1.494	1.403	2.990	1.925
Public Authority - Quarterly - 1/31/07 (Total Class)						
Average Day in Peak Quarter	870	708	727	612	676	
Average Day for Year	765	628	627	554	578	
Average Day-Peak Quarter/Average Day-Year	1.137	1.128	1.158	1.103	1.169	1.139
Public Authority - Quarterly - 2/26/07 (Total Class)						
Average Day in Peak Quarter	132	157	121	175	137	
Average Day for Year	93	96	82	91	89	
Average Day-Peak Quarter/Average Day-Year	1.418	1.635	1.477	1.912	1.551	1.599
Public Authority - Quarterly - 2/28/07 (Total Class)						
Average Day in Peak Quarter	473	345	318	307	350	
Average Day for Year	357	310	313	300	308	
Average Day-Peak Quarter/Average Day-Year	1.324	1.115	1.017	1.022	1.137	1.123
Public Authority - Quarterly - 3/5/07 (Total Class)						
Average Day in Peak Quarter	4	3	1	8	4	
Average Day for Year	2	1	0	3	3	
Average Day-Peak Quarter/Average Day-Year	1.708	2.062	4.067	2.596	1.305	2.347
Public Authority - Quarterly - 3/19/07 (Total Class)						
Average Day in Peak Quarter	3	3	5	4	2	
Average Day for Year	1	1	2	1	1	
Average Day-Peak Quarter/Average Day-Year	3.244	3.065	3.596	3.350	3.139	3.279
Public Authority - Quarterly - 3/26/07 (Total Class)						
Average Day in Peak Quarter	78	214	294	129	175	
Average Day for Year	40	114	114	71	82	
Average Day-Peak Quarter/Average Day-Year	1.933	1.872	2.589	1.816	2.125	2.067
Public Authority - Quarterly - 3/29/07 (Total Class)						
Average Day in Peak Quarter	1,876	1,916	2,270	2,238	2,449	
Average Day for Year	1,748	1,672	1,877	1,877	2,162	
Average Day-Peak Quarter/Average Day-Year	1.073	1.146	1.210	1.192	1.133	1.151
Public Authority - Monthly (Total Class)						
Average Day in Peak Quarter	**3,689**	**3,942**	**3,841**	**3,786**	**3,967**	
Average Day for Year	**3,060**	**3,390**	**3,354**	**3,435**	**3,375**	
Average Day-Peak Quarter/Average Day-Year	**1.206**	**1.163**	**1.145**	**1.102**	**1.175**	**1.158**

Note: Usage is in hundred cubic feet (CCF).

From this data, it appears that the larger customers in the public authority class tend to exhibit similar peak quarter-to-average consumption ratios as compared to the remainder of the customers, for both the customers billed monthly and those billed quarterly. These larger customers make up just under half of the consumption for this class.

Graphical Summary

Charts 2-7 illustrate the pattern of retail nonresidential water consumption for the period 2007-2011. The utility bills a portion of its nonresidential customers each week, so the metering period for each billing group is different. Therefore, it is not possible to sum the total consumption of all retail nonresidential customers over the same period. For customers billed on a quarterly frequency, the quarterly billed consumption is shown separately for each of the 12 billing groups within each class. For customers billed on a monthly frequency, the monthly consumption was summed and the monthly consumption patterns are compared by year.

These graphs reveal several important characteristics of the patterns of nonresidential water consumption. First, the commercial customer class exhibits a marked pattern of the peak quarter or month of consumption occurring in the third quarter of the year (July, August and September consumption). Industrial customers have a similar pattern of peak consumption during the summer months, but the pattern is less pronounced. Public authority customers that are billed on a quarterly frequency tend to have the highest consumption during the third quarter of the year. However, data for the customers billed on a monthly basis indicate that for two of the years during the analysis period, these customers experienced peak consumption during other times of the year. In 2010, peak consumption occurred in February, while in 2011, peak consumption occurred in May. However, based on trends for the remainder of those years, plus the three preceding years, those two months of high usage were most likely anomalies, and they did not exhibit usage that was extraordinarily higher than the months where a peak would be expected. For the years 2007-2009, peak consumption occurred in August.

Chart 2 - Quarterly Billed Commercial Customers, Water Consumption by Quarter and Billing Group, 2007-2011

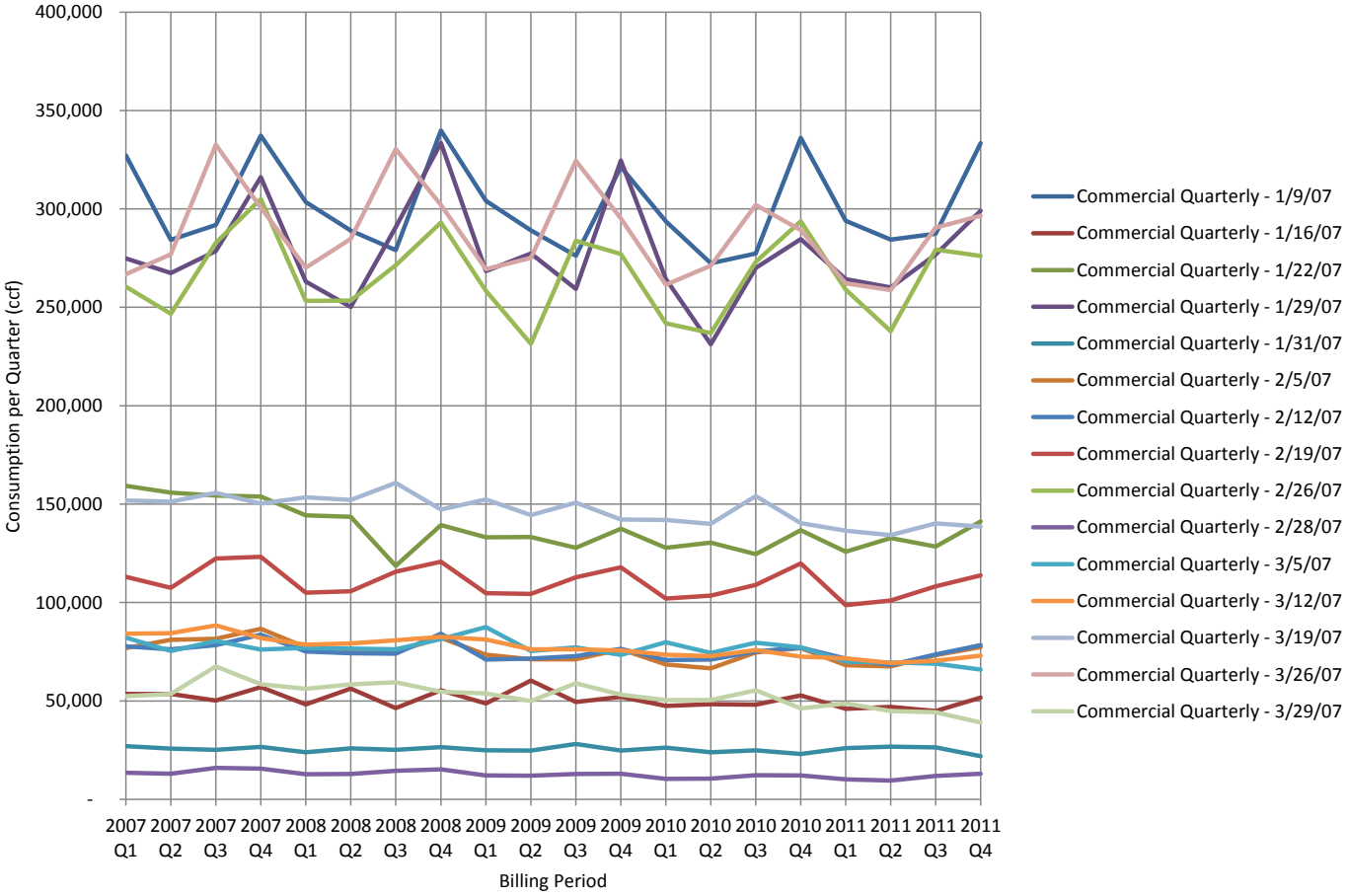


Chart 3 - Monthly Billed Commercial Customers, Water Consumption by Month and Year, 2007-2011

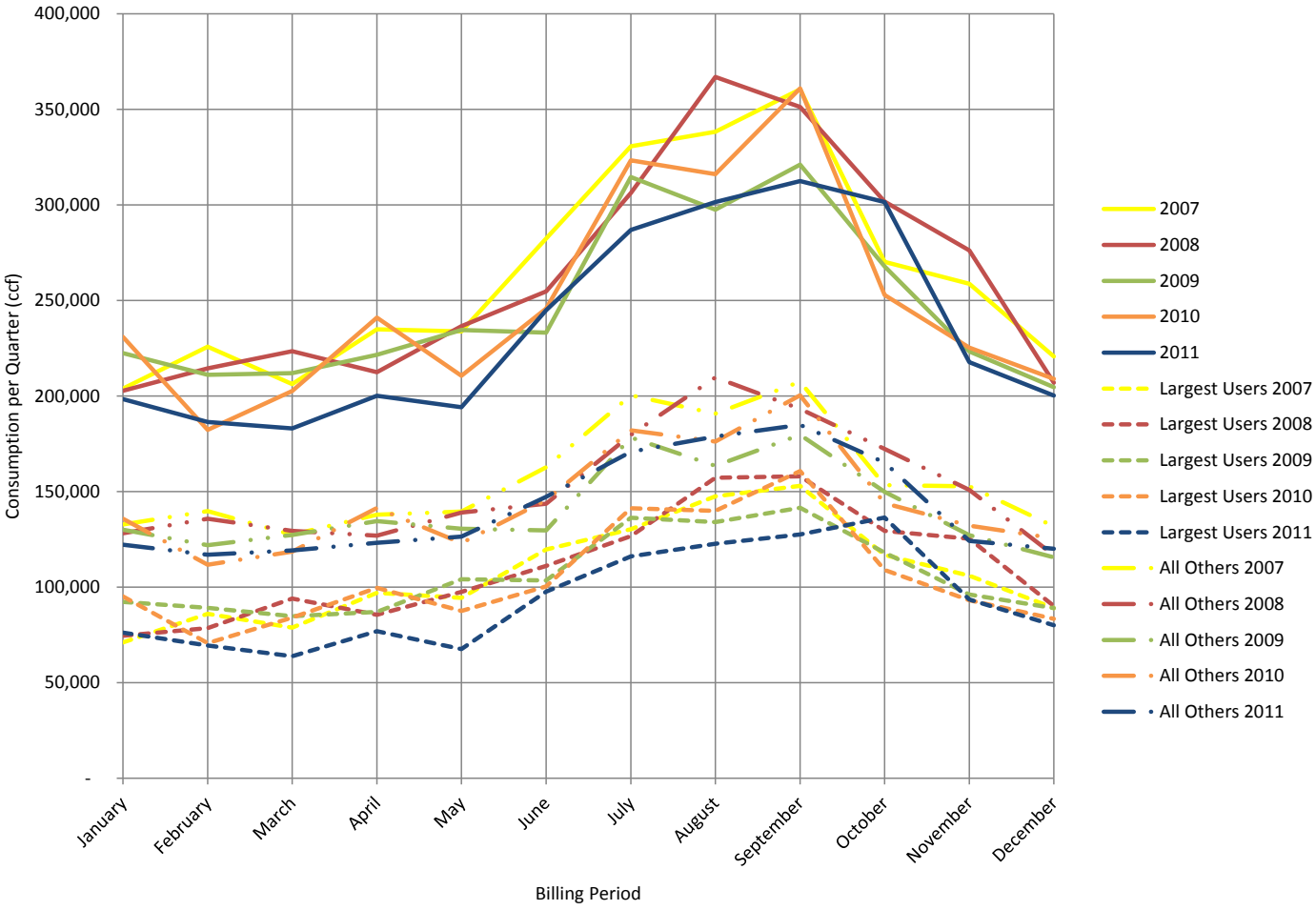


Chart 4 - Quarterly Billed Industrial Customers, Water Consumption by Quarter and Billing Group, 2007-2011

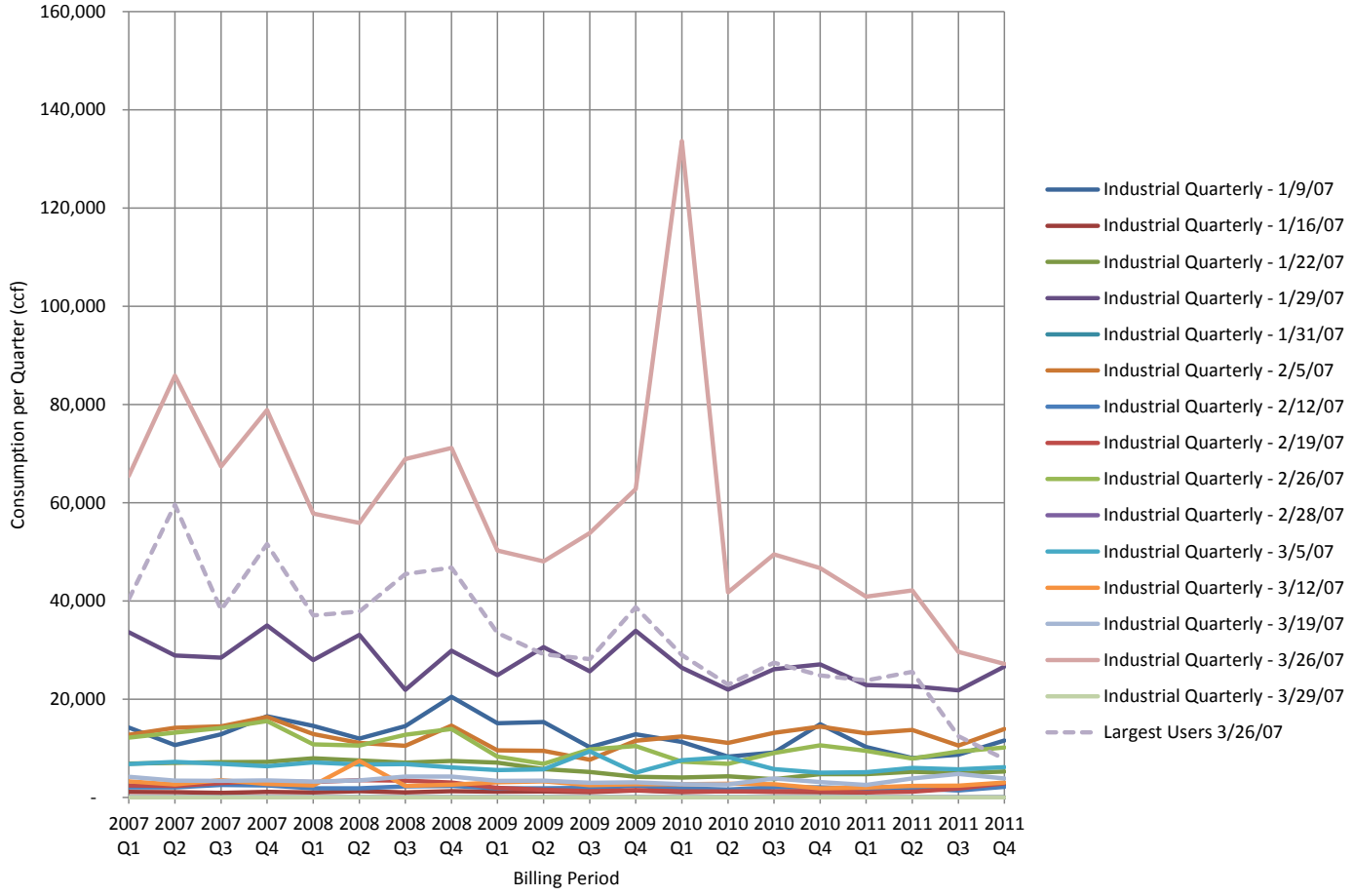


Chart 5 - Monthly Billed Industrial Customers, Water Consumption by Month and Year, 2007-2011

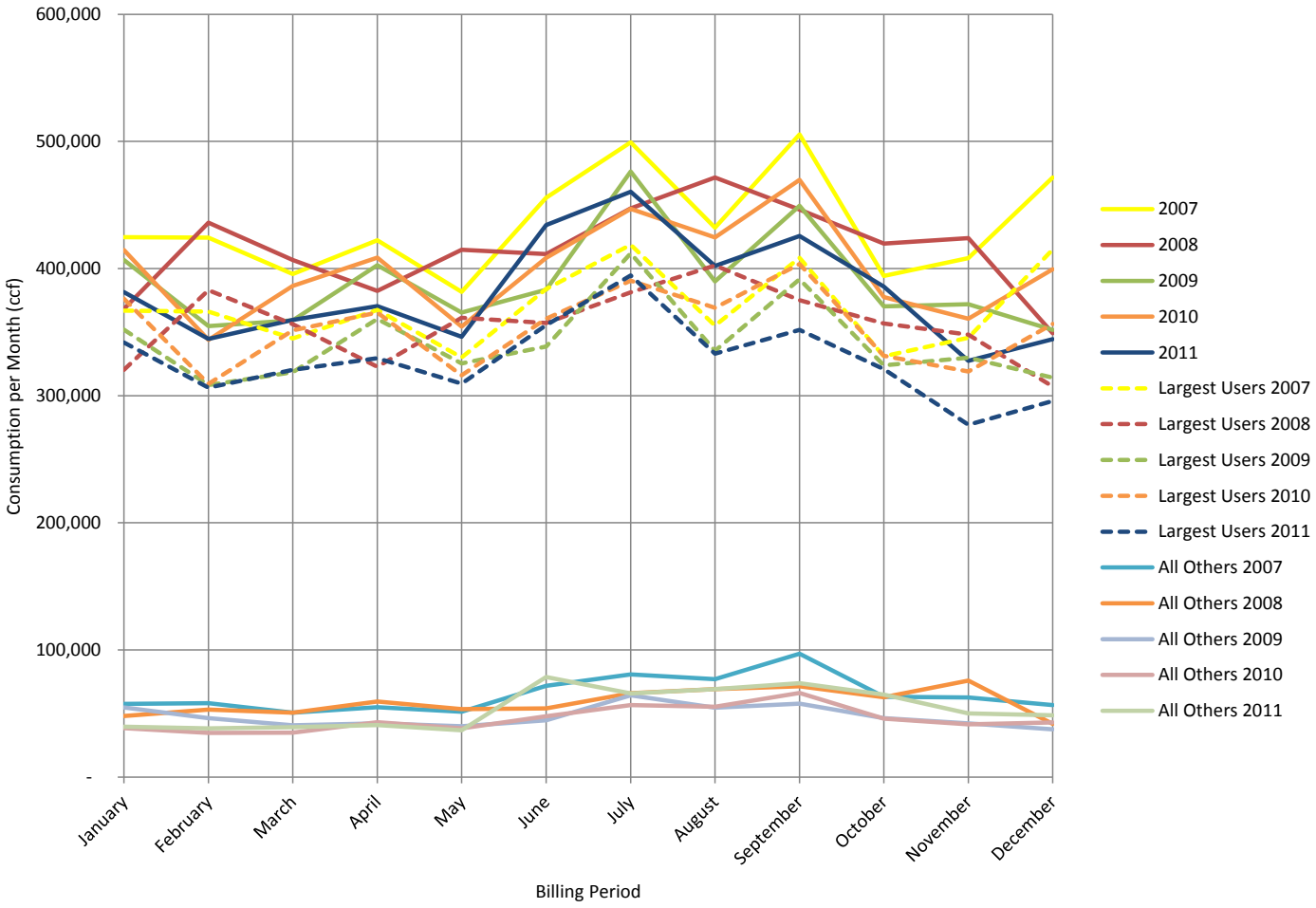


Chart 6 - Quarterly Billed Public Authority Customers, Water Consumption by Quarter and Billing Group, 2007-2011

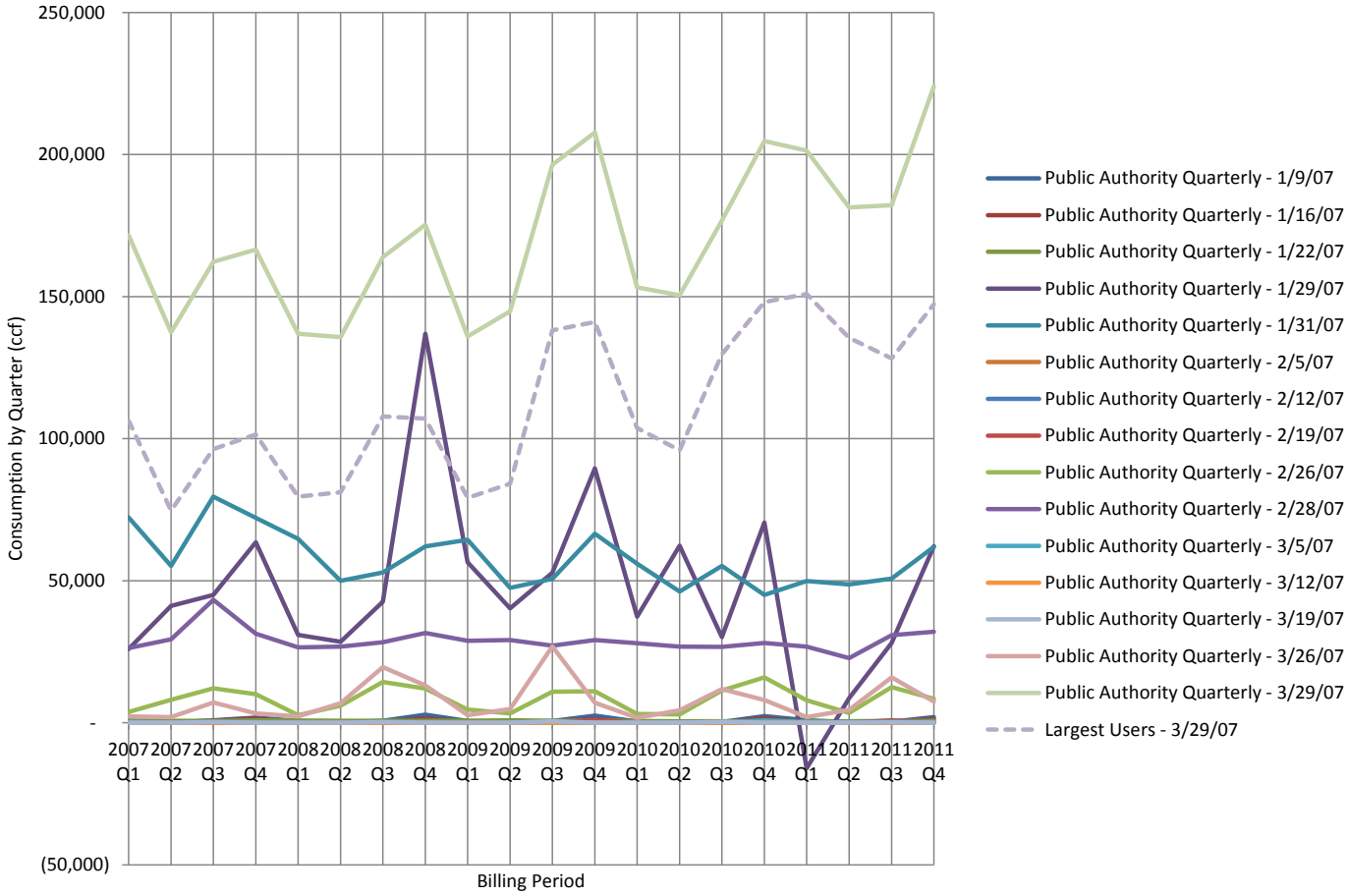
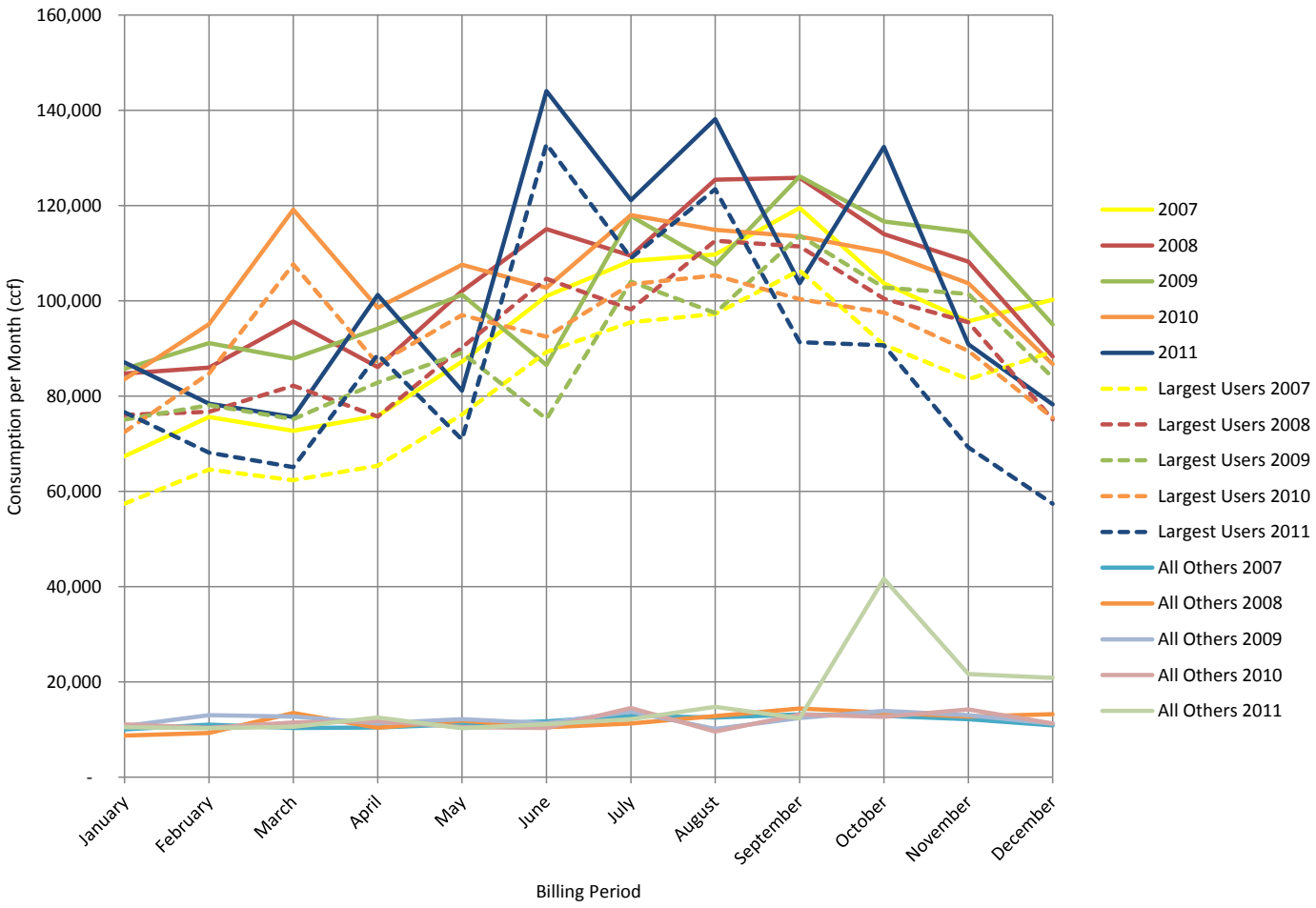


Chart 7 - Monthly Billed Public Authority Customers, Water Consumption by Month and Year, 2007-2011



SECTION IV: SELECTED RETAIL SAMPLING METHODOLOGY

INTRODUCTION

The goal of the sampling methodology was to determine, for each customer class, a sample size that was large enough and included the correct mix of customers, so that the sample would exhibit coincident peaks similar to those of the customer class as a whole. As explained above, the typical method of evaluating sample size (based on standard deviation) is not applicable to the variables that this study was attempting to measure. This study was attempting to choose a sample with similar coincident max day and max hour ratios rather than a sample with mean ratios that are similar to the mean ratios of the customer class as a whole. As described above, the historical data for each customer class was analyzed to identify patterns in peak quarterly or monthly demand compared to average day demand. Historical data from each customer class was also analyzed to identify patterns in peak quarterly or monthly usage by geography or socio-economic class for residential customers and by size of customer for the nonresidential classes. This analysis was used to determine the appropriate sample size and composition for each class that would represent the mix of characteristics of the class as a whole. The selected approach and rationale for the sampling methodology for each class is as described below.

RESIDENTIAL

The residential customer class is comprised of a large number of customers with relatively small and homogeneous demand per customer (as compared to other customer classes). The demand patterns of the class as a whole are the result of thousands of individual customers' total water demand and ratios of peak demand to average demand, as well as the timing of each individual customer's peak demand. There is not a particular segment of the class whose demand patterns drive the demand patterns of the class as a whole. There are, however, observable differences in demand patterns in different geographic areas of the retail service area.

The utility's three major retail billing groups include a group that primarily includes the central part of the City of Milwaukee, a group that is primarily comprised of suburban retail customers, and a third group that covers the north and northwest part of Milwaukee. As revealed by the analysis of historical water demand, meter reading routes in the older, more densely developed areas have had lower ratios of peak-to-average usage during the past five years, while the newer, more suburban development displayed higher ratios. The north and northwest area of the City, which contains a mix of development patterns, had a mix of peak ratios.

Based on these observed patterns, it was determined that the sample of residential customers should include customers from meter reading routes in each of the three major billing groups. The following methodology was used to choose the proposed routes from which to select the sample of retail residential customers:

1. Four meter reading routes were selected at random from each of the three major billing groups, ensuring that customers would be selected from each of the major geographic areas within the retail service area. The following routes were selected: 112, 113, 117, 131, 244, 245, 259, 261, 377, 379, 384, and 394.

2. Housing and socio-economic data from the 2010 Census was obtained at the census tract level for each of the selected routes. The selected routes encompassed parts of 35 census tracts. This data was analyzed and compared to the same data for the entire retail service area to verify that the selected routes are representative of the retail service area in terms of housing stock and key socio-economic characteristics.

The comparison of the initially selected routes to the retail service area as a whole indicated that the selected routes were similar to the retail service as a whole in many respects. However, the selected routes were significantly different than the retail area as a whole in the following demographic characteristics:

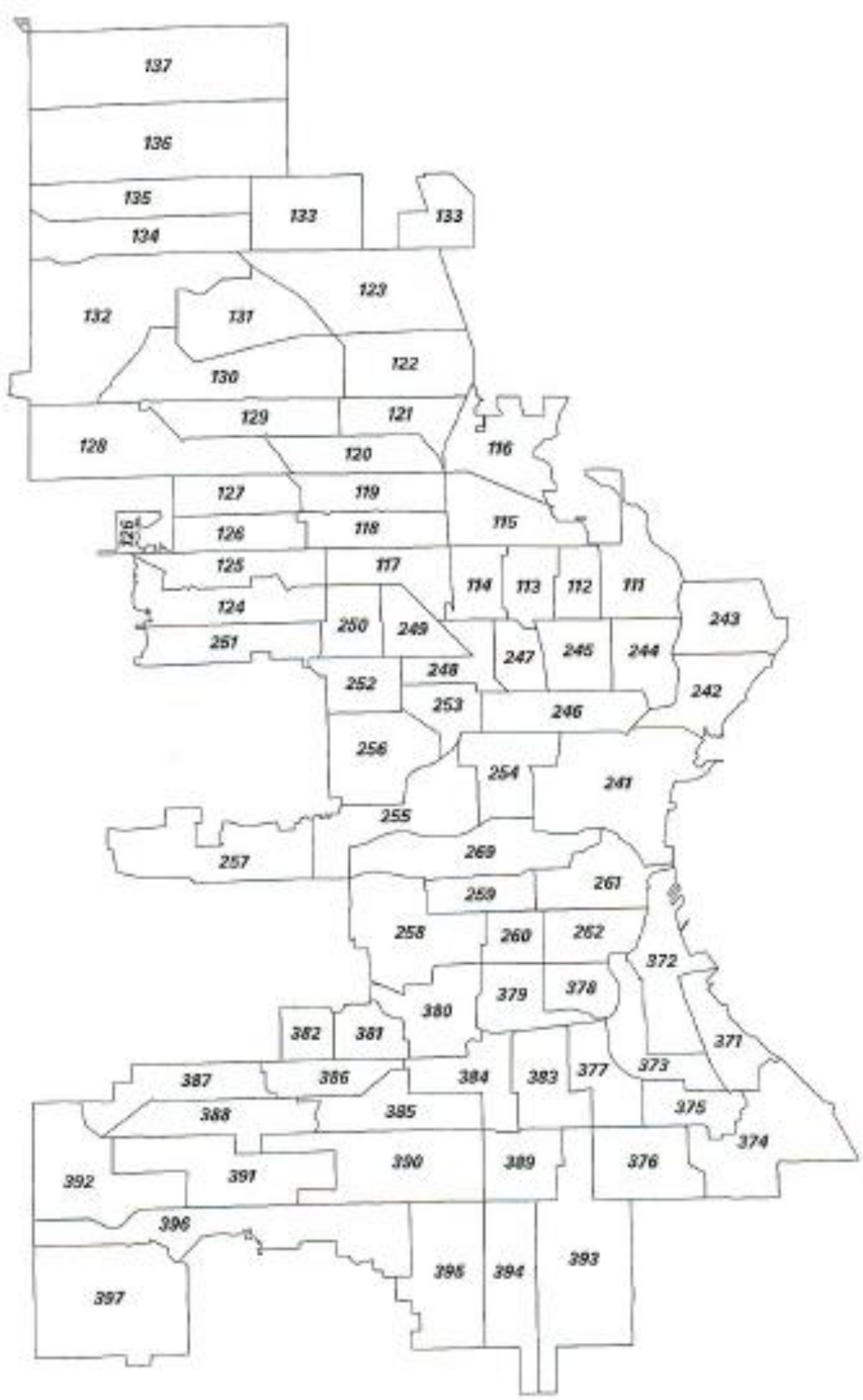
- The percentages of family households and households with children under 18 for the selected routes are higher than the retail service area.
- The percentage of duplexes is higher and the percentage of multi-family units is lower than the retail service area as a whole.
- The percentage of homes built before 1939 is higher and the percentage of homes built during the 1950's and 1970's are lower as compared to the retail service area as a whole.
- A higher percentage of households in owner-occupied housing pay more than 35% of their monthly income for their mortgage as compared to the retail service area.

Following the initial selection and analysis of routes, Route 113 was replaced with Route 136 and the analysis was repeated for the selected routes versus the retail service area. The selected routes still differed from the retail service area as a whole. However, the selected routes were more similar to the retail service area as whole. Based on this analysis, Routes 112, 117, 131, 136, 244, 245, 259, 261, 377, 379, 384, and 394 were used for the residential sampling. A map of the various billing routes is shown on the following page.

The following procedures were used to select the specific customer accounts for data collection:

1. The utility provided a list of customer accounts and metered water usage by customer for the past 8 quarters for each of the selected meter reading routes.
2. A group of thirty customers was randomly selected from each of the twelve routes.
3. The historical water usage for each of the selected accounts was then reviewed and analyzed to eliminate unusable accounts and evaluate the adequacy of the sample size. Of the 360 initial customers, a total of 28 accounts were removed from the sample due to sporadic water use.

Map 2 - Billing Routes in Retail Service Area



COMMERCIAL

Commercial customers comprise the second largest customer class. They exhibit diversity in terms of total consumption per customer and the degree of seasonal variation in consumption. The consumption patterns of the large number of small customers appear to drive the peaking patterns of the class as a whole, while the largest customers differ from the rest of the class. Therefore, for purposes of this study, it was assumed that the sample should be comprised primarily of the smaller customers billed on a quarterly basis, in proportion to the percentage of those billed quarterly for the population.

This assumption was tested by computing the coincident ratio of peak quarter to average day consumption for the years 2007-2011 for five random samples of 200 non-residential customers. This is summarized in Table 10. As the table shows, the random sampling resulted in varying numbers of commercial customers and different proportions of those billed monthly versus quarterly. The coincident ratios of average day during peak quarter to average day for the year also varied among the samples. The statistics of the individual customers sampled show that the average and standard deviation of MQ:AD ratios within each sample do not appear to have any correlation with that of the respective sample as a whole. In looking further at the specific customers that were sampled in this comparison, the key factor in determining the entire sample's peak quarter ratio was the specific mix of customers and their water consumption patterns. A large customer impacts the results of a sample disproportionately to its impact on the entire utility commercial class. For this reason, a sample was taken that mirrors the entire class as much as possible. This is done by including a similar proportion of the number and usage of monthly-billed vs. quarterly-billed customers and testing for consistency with historical MQ:AD ratios between the sample and the population. As long as the mix of customers within the sample is appropriate, the analysis appears to show that a sample size of slightly less than 200 should be sufficient to provide good data.

Commercial customers exhibited a strong pattern of peak consumption in the third quarter of the year (billed in the fourth quarter). Therefore, it was determined that the sample period should capture at least the third quarter of the year (July, August, September).

INDUSTRIAL

The peak ratio for the industrial customer class is largely determined by those customers billed monthly, and, within that subset group, the very largest customers that are billed monthly. These 51 largest customers represent approximately 78 percent of the consumption for the industrial class. Therefore, for purposes of this study it was determined to sample as many of these largest customers as possible. The utility identified 40 of these customers with meters capable of having ERTs installed.

Industrial customers exhibited a slight pattern of peak consumption in the third quarter of the year (billed in the fourth quarter). Therefore, it was determined that the sample period should capture at least the third quarter of the year (July, August, September).

PUBLIC AUTHORITY

From this data, it appears that the larger customers in the public authority class tend to exhibit similar peak quarter-to-average consumption ratios as compared to the remainder of the customers, for both the customers billed monthly and those billed quarterly. These larger customers make up just under half of the consumption for this class. Since the largest customers in this class drive the peak consumption of the class as whole, it was determined to sample as many of these large customers as possible. The utility initially identified 17 of these customers with meters capable of having ERTs installed.

Public authority customers exhibited varying patterns of consumption, with a longer period of peak consumption in the third quarter of the year potentially extending into the beginning of the fourth quarter. It was determined that the sample period should capture the third quarter of the year, plus the first month of the fourth quarter (October).

Table 10 - Summary Statistics of Peak Quarter to Average Day Consumption for Example Samples of Commercial Customers, 2007-2011

	2007					2008					2009					2010					2011				
Sample Number ---------->	1A	2A	3A	4A	5A	1A	2A	3A	4A	5A	1A	2A	3A	4A	5A	1A	2A	3A	4A	5A	1A	2A	3A	4A	5A
Commercial Monthly																									
Number	6	5	9	8	11	6	5	9	8	11	6	5	9	8	11	6	5	9	8	11	6	5	9	8	11
Percent	3.3%	2.9%	4.9%	4.5%	6.1%	3.3%	2.9%	4.9%	4.5%	6.1%	3.3%	2.9%	4.9%	4.5%	6.1%	3.3%	2.9%	4.9%	4.5%	6.1%	3.3%	2.9%	4.9%	4.5%	6.1%
Commercial Quarterly																									
Number	177	169	174	171	169	177	169	174	171	169	177	169	174	171	169	177	169	174	171	169	177	169	174	171	169
Percent	96.7%	97.1%	95.1%	95.5%	93.9%	96.7%	97.1%	95.1%	95.5%	93.9%	96.7%	97.1%	95.1%	95.5%	93.9%	96.7%	97.1%	95.1%	95.5%	93.9%	96.7%	97.1%	95.1%	95.5%	93.9%
Total Sample	183	174	183	179	180	183	174	183	179	180	183	174	183	179	180	183	174	183	179	180	183	174	183	179	180
Peak Qtr Ratio, Noncoincident	1.37	1.30	1.47	1.42	1.49	1.41	1.55	1.51	1.37	1.38	1.62	1.45	1.38	1.37	1.45	1.45	1.52	1.49	1.56	1.40	1.34	1.44	1.61	1.38	1.37
Peak Qtr Ratio Coincident	**1.09**	**1.05**	**1.16**	**1.05**	**1.08**	**1.06**	**1.14**	**1.18**	**1.06**	**1.08**	**1.06**	**1.13**	**1.11**	**1.13**	**1.07**	**1.19**	**1.34**	**1.20**	**1.08**	**1.10**	**1.03**	**1.15**	**1.16**	**1.10**	**1.09**
Average	1.49	1.50	1.48	1.68	1.66	1.73	1.51	1.72	1.53	1.75	1.62	1.55	1.61	1.68	1.53	1.66	1.57	1.46	1.87	1.64	1.74	1.43	1.58	1.70	1.68
Median	1.26	1.22	1.27	1.33	1.28	1.31	1.24	1.26	1.22	1.30	1.27	1.25	1.27	1.29	1.26	1.28	1.29	1.22	1.33	1.29	1.26	1.23	1.26	1.29	1.27
Standard Dev	0.67	0.70	0.60	0.84	1.23	1.56	0.77	3.33	0.69	1.40	0.85	0.72	0.87	0.86	0.79	1.17	0.81	0.71	1.70	1.18	2.78	0.49	1.11	1.19	1.23
Population	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variance	0.45	0.49	0.36	0.71	1.51	2.45	0.60	11.11	0.47	1.96	0.71	0.52	0.76	0.75	0.63	1.38	0.66	0.50	2.88	1.39	7.71	0.24	1.22	1.42	1.52
Sample Size Calc (@90% LOS)	121.00	134.00	99.00	192.00	409.00	662.00	162.00	3,008.00	128.00	530.00	194.00	140.00	206.00	203.00	171.00	373.00	178.00	136.00	780.00	376.00	2,086.00	66.00	331.00	384.00	413.00
Assumed Standard Error	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Minimum	1.00	0.44	1.00	1.02	1.02	1.00	0.94	1.00	1.00	1.00	1.00	1.01	1.00	1.03	1.00	1.03	1.04	1.00	1.00	1.03	1.00	1.02	1.00	1.03	1.01
Maximum	7.07	4.00	4.28	4.00	11.97	16.00	8.00	43.64	4.00	12.00	5.89	4.00	7.98	5.98	5.98	11.97	7.87	5.98	11.97	11.97	35.90	4.00	11.97	11.97	11.97
1.00-1.10	31.00	27.00	30.00	28.00	27.00	20.00	25.00	30.00	29.00	31.00	28.00	37.00	27.00	17.00	25.00	26.00	22.00	30.00	25.00	22.00	29.00	33.00	29.00	21.00	24.00
1.10-1.20	31.00	45.00	31.00	30.00	38.00	38.00	43.00	39.00	40.00	24.00	33.00	25.00	34.00	37.00	33.00	41.00	35.00	44.00	28.00	38.00	41.00	36.00	37.00	30.00	35.00
1.20-1.30	26.00	21.00	31.00	15.00	16.00	25.00	20.00	22.00	14.00	25.00	29.00	24.00	24.00	26.00	22.00	21.00	23.00	23.00	18.00	22.00	18.00	21.00	23.00	24.00	22.00
1.30-1.40	19.00	14.00	17.00	18.00	11.00	14.00	12.00	15.00	15.00	15.00	9.00	12.00	15.00	10.00	19.00	11.00	15.00	20.00	14.00	20.00	21.00	11.00	16.00	10.00	12.00
1.40-1.50	10.00	10.00	11.00	7.00	13.00	17.00	6.00	11.00	5.00	17.00	13.00	11.00	9.00	8.00	8.00	13.00	10.00	9.00	11.00	11.00	11.00	12.00	14.00	10.00	11.00
1.50-1.60	9.00	3.00	13.00	13.00	13.00	4.00	13.00	8.00	4.00	4.00	13.00	8.00	3.00	7.00	7.00	15.00	8.00	6.00	11.00	4.00	4.00	8.00	3.00	6.00	6.00
1.60-1.70	4.00	3.00	4.00	3.00	3.00	8.00	4.00	7.00	7.00	6.00	3.00	2.00	8.00	2.00	10.00	3.00	4.00	3.00	7.00	5.00	5.00	6.00	6.00	10.00	5.00
1.70-1.80	4.00	6.00	4.00	3.00	6.00	4.00	3.00	5.00	6.00	6.00	8.00	8.00	9.00	7.00	4.00	3.00	9.00	7.00	-	6.00	6.00	4.00	8.00	3.00	5.00
1.80-1.90	4.00	2.00	2.00	2.00	4.00	4.00	5.00	3.00	4.00	2.00	1.00	3.00	6.00	4.00	-	3.00	2.00	2.00	2.00	2.00	3.00	4.00	3.00	2.00	1.00
1.90-2.00	6.00	2.00	3.00	4.00	1.00	3.00	3.00	4.00	5.00	2.00	5.00	3.00	1.00	4.00	3.00	6.00	9.00	2.00	6.00	5.00	5.00	6.00	5.00	8.00	4.00
2.00-2.10	3.00	-	2.00	5.00	-	3.00	4.00	-	1.00	1.00	2.00	2.00	-	3.00	3.00	1.00	1.00	-	-	2.00	2.00	2.00	2.00	2.00	3.00
2.10-2.20	5.00	3.00	1.00	1.00	3.00	6.00	1.00	4.00	1.00	1.00	1.00	2.00	3.00	-	-	2.00	3.00	-	2.00	1.00	-	2.00	1.00	1.00	4.00
2.20-2.30	2.00	2.00	1.00	4.00	2.00	3.00	3.00	2.00	1.00	2.00	1.00	2.00	2.00	5.00	2.00	2.00	1.00	-	2.00	3.00	3.00	-	1.00	2.00	4.00
2.30-2.40	4.00	2.00	3.00	1.00	1.00	3.00	-	3.00	2.00	-	-	1.00	3.00	-	1.00	4.00	2.00	-	2.00	1.00	2.00	1.00	-	-	1.00
2.40-2.50	-	1.00	-	1.00	2.00	-	1.00	-	3.00	1.00	3.00	4.00	5.00	1.00	2.00	2.00	2.00	2.00	1.00	-	1.00	-	1.00	-	1.00
2.50-2.60	1.00	1.00	1.00	1.00	2.00	-	1.00	2.00	-	-	1.00	-	1.00	2.00	-	-	-	1.00	1.00	-	1.00	3.00	-	-	3.00
2.60-2.70	2.00	1.00	2.00	-	-	2.00	2.00	2.00	2.00	1.00	-	1.00	1.00	2.00	3.00	1.00	-	-	2.00	1.00	-	2.00	1.00	2.00	1.00
2.70-2.80	-	1.00	2.00	-	1.00	-	2.00	-	-	2.00	-	1.00	-	-	2.00	1.00	-	-	-	1.00	-	1.00	1.00	-	1.00
2.80-2.90	-	-	-	1.00	1.00	-	-	-	1.00	1.00	1.00	1.00	-	-	-	-	-	3.00	1.00	2.00	-	1.00	-	-	-
2.90-3.00	1.00	1.00	1.00	2.00	1.00	2.00	-	1.00	1.00	2.00	3.00	1.00	2.00	1.00	1.00	-	3.00	-	-	-	-	-	-	2.00	1.00
3.00-3.10	-	2.00	-	2.00	-	-	-	-	1.00	-	2.00	-	-	2.00	-	-	-	-	-	1.00	-	-	-	-	-
3.10-3.20	-	1.00	-	-	-	2.00	-	2.00	-	1.00	2.00	-	-	1.00	-	-	-	-	-	-	1.00	-	1.00	1.00	-
3.20-3.30	1.00	-	-	1.00	-	-	-	-	2.00	-	2.00	-	-	1.00	-	-	-	-	1.00	-	2.00	-	-	-	-
3.30-3.40	-	-	-	2.00	1.00	-	-	-	-	1.00	1.00	-	-	1.00	1.00	-	-	-	2.00	1.00	-	-	1.00	-	2.00
3.40-3.50	-	-	1.00	2.00	-	-	1.00	-	-	1.00	-	-	-	-	1.00	-	-	2.00	-	-	-	-	-	1.00	1.00
>3.50	3.00	7.00	5.00	11.00	10.00	10.00	5.00	4.00	6.00	13.00	8.00	9.00	10.00	11.00	4.00	12.00	7.00	6.00	14.00	9.00	9.00	2.00	9.00	11.00	8.00

SECTION V: WHOLESALE ANALYSIS

SUMMARY OF WHOLESALE DATA

The purpose of this analysis was to determine appropriate peak day and peak hour ratios based on actual pumping data for each wholesale customer, to the extent that the data is available, or through extrapolation using other available data.

The utility provided all available hourly pumping data for its wholesale customers through October of 2013. As of that date, the utility had meters capable of reading and storing hourly pumpage for all of its wholesale customers, except Shorewood and Milwaukee County Grounds. For the other customers, the data was analyzed beginning with the first date there was reliable data available, which varied by customer and is shown in the analysis.

Data Adjustments

Each day and hour of data was thoroughly reviewed to ensure accuracy of the data. The data included both the hourly pumpage and a running total for the period of time of reading for each meter. During the review, it was discovered that there were periods of time of varying lengths for each wholesale customer when some meter data transmission froze for a time before kicking back in at a later time, although the meters continued to record water usage properly. When the transmission at these times returned, the running totals had jumped ahead to record the current running water usage total. Because of this, if the data was read without adjustment, there would be days and hours of extreme consumption that did not reflect actual consumption. In order to correct for this situation and ensure the most accurate analysis and fair method to determine peak ratios, an adjustment was made. The analysis averaged the pumpage during the periods that had frozen data transmission over each hour the meter reading points were stopped. This had the effect of ensuring that the total (and, therefore, average) water pumpage for each customer was correct, while also ensuring that peak consumption would not be overstated. If anything, it is possible that during these times, there could have been a peak day of consumption that was not recorded. However, because of the data, the analysis must assume stable usage for these meters during these periods and only consider recorded peaks in performing the calculations of peak ratios.

The following graphs display a summary of daily and hourly pumpage to each customer, beginning with the first date of available data, through October 2013:

Village of Brown Deer

Brown Deer had pumping data beginning on 4/27/2012. Chart 8 shows total daily pumpage to Brown Deer each day through the end of October 2013. The second vertical line on the graph indicates a time of one year from the beginning of the period. The day with the largest consumption over this time was 7/12/2012, with a secondary peak day of consumption on 10/31/2012. The day of peak consumption during 2013 was 7/18/2013. All usage displayed on the charts is in units of hundred cubic feet (CCF).

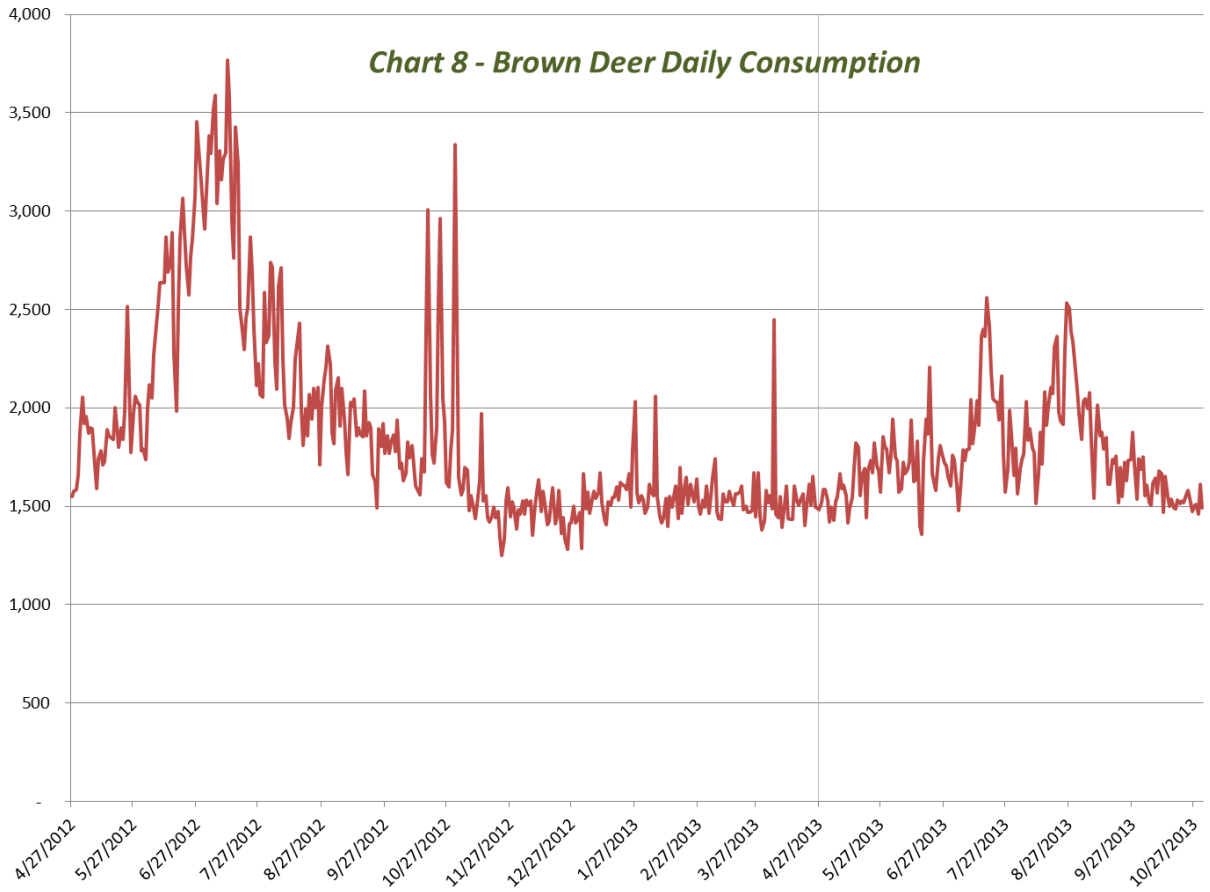
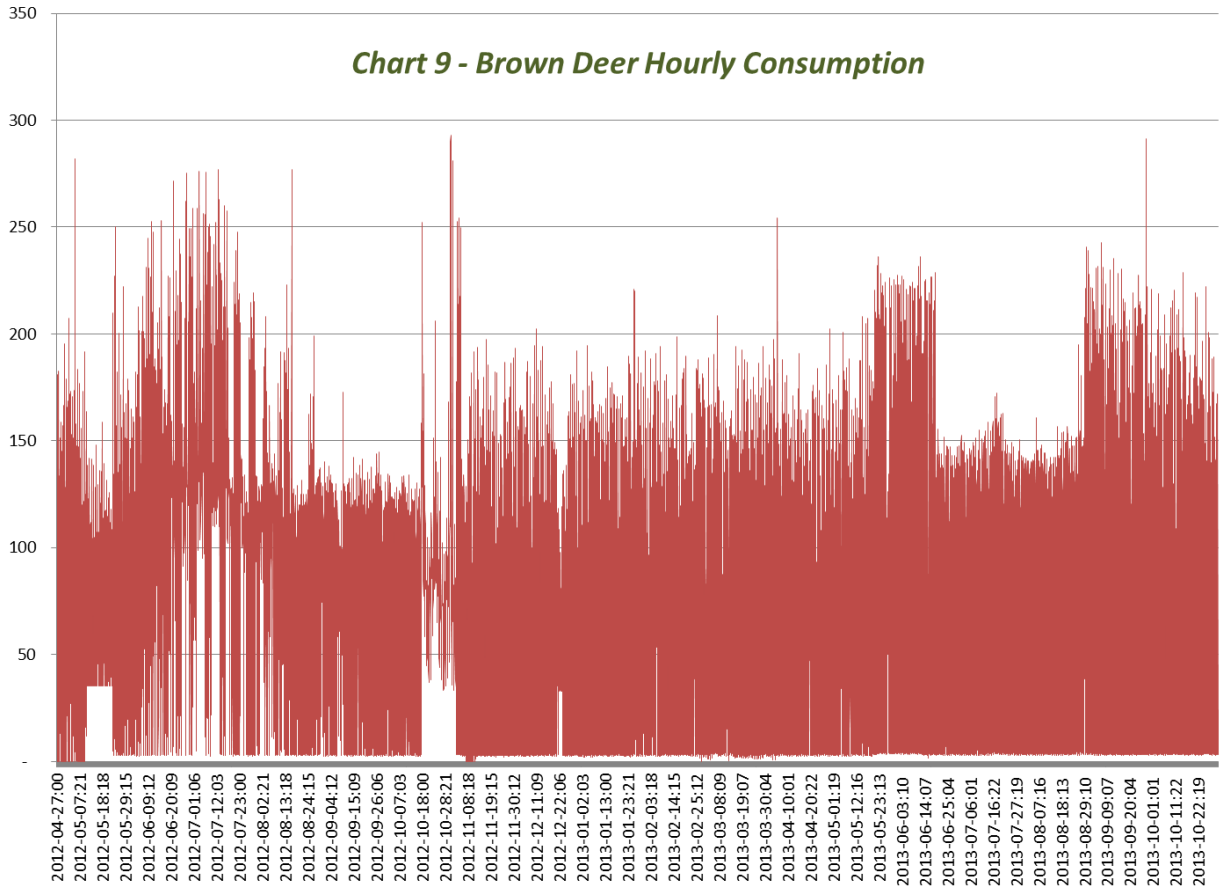


Chart 9 shows total pumpage for each hour of each day beginning on 4/27/2012. The nature of the data makes graphical representation difficult, as there is considerable variability in hourly pumpage of the customer (which results in the solid block graph, rather than the clean line displayed in the daily data). It is noteworthy that daily pumpage totals and peak pumpage days are relatively independent from occurrences of peak hour pumpage and patterns of hourly pumpage throughout the day. It appears that how the water systems are operated make much of a difference in determining the peak hour pumpage of each wholesale customer. For Brown Deer, the peak hour for the entire period occurred during hour 13 of 10/31/2012. There were several additional peak hours of nearly the same magnitude on days during May, July and August of 2012 and September of 2013.



Data Adjustments

After speaking with the utility operator for Brown Deer, it was learned that the spike in water usage during October 2012 was due to a standpipe being taken out of service for inspection by the Department of Natural Resources. This resulted in numerous main breaks due to the change in pressure while the standpipe was out of service. Because of this, it was determined that it would be appropriate to normalize the data during that timeframe and recalculate the resulting peak day and peak hour ratios. The following charts show the resulting adjusted data. Chart 10 shows the adjusted daily usage by Brown Deer overlaid on the original data; Chart 11 shows the adjusted hourly data overlaid on the original for the time period before, during and after the time the standpipe was out of service. As the charts show, this results in eliminating the secondary peak day usage during October 2012 as well as reducing the abnormal peak hourly usage during that same time.

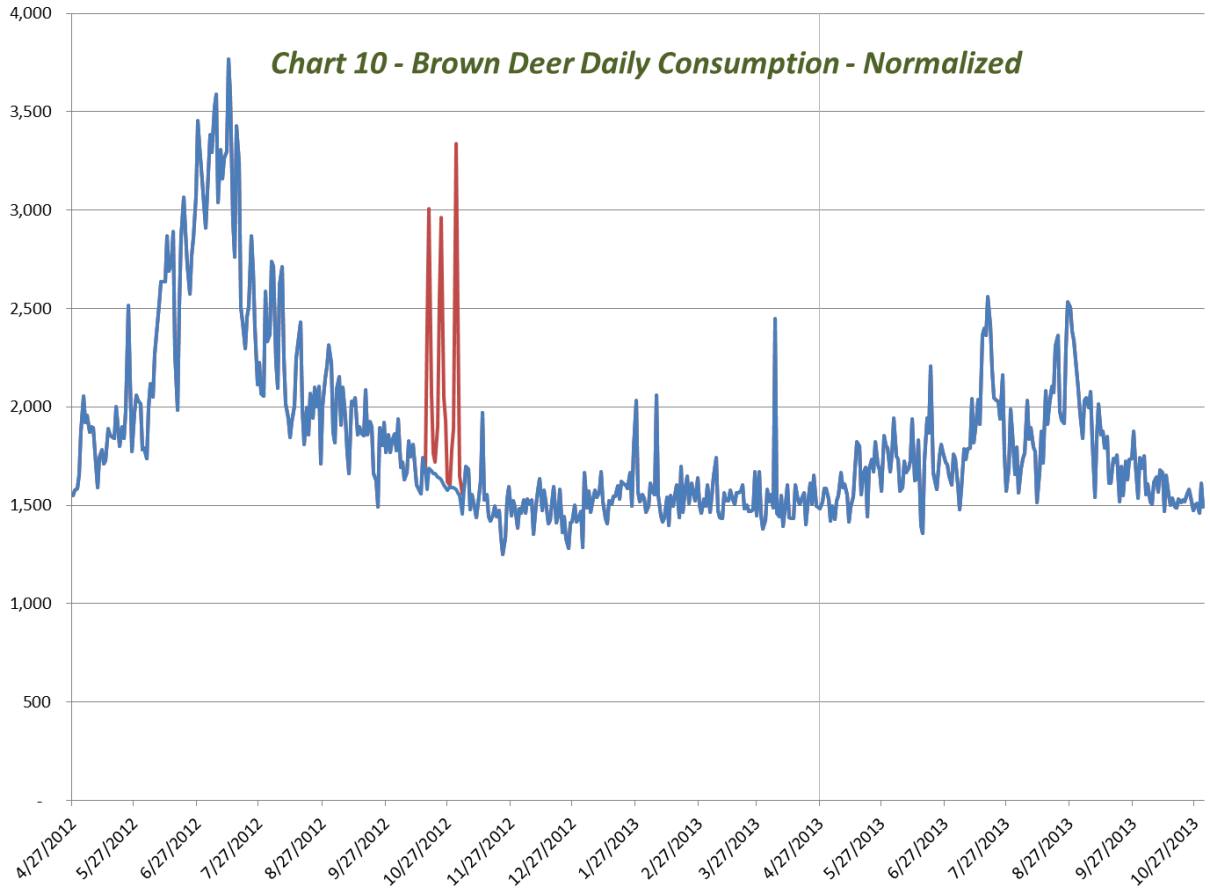
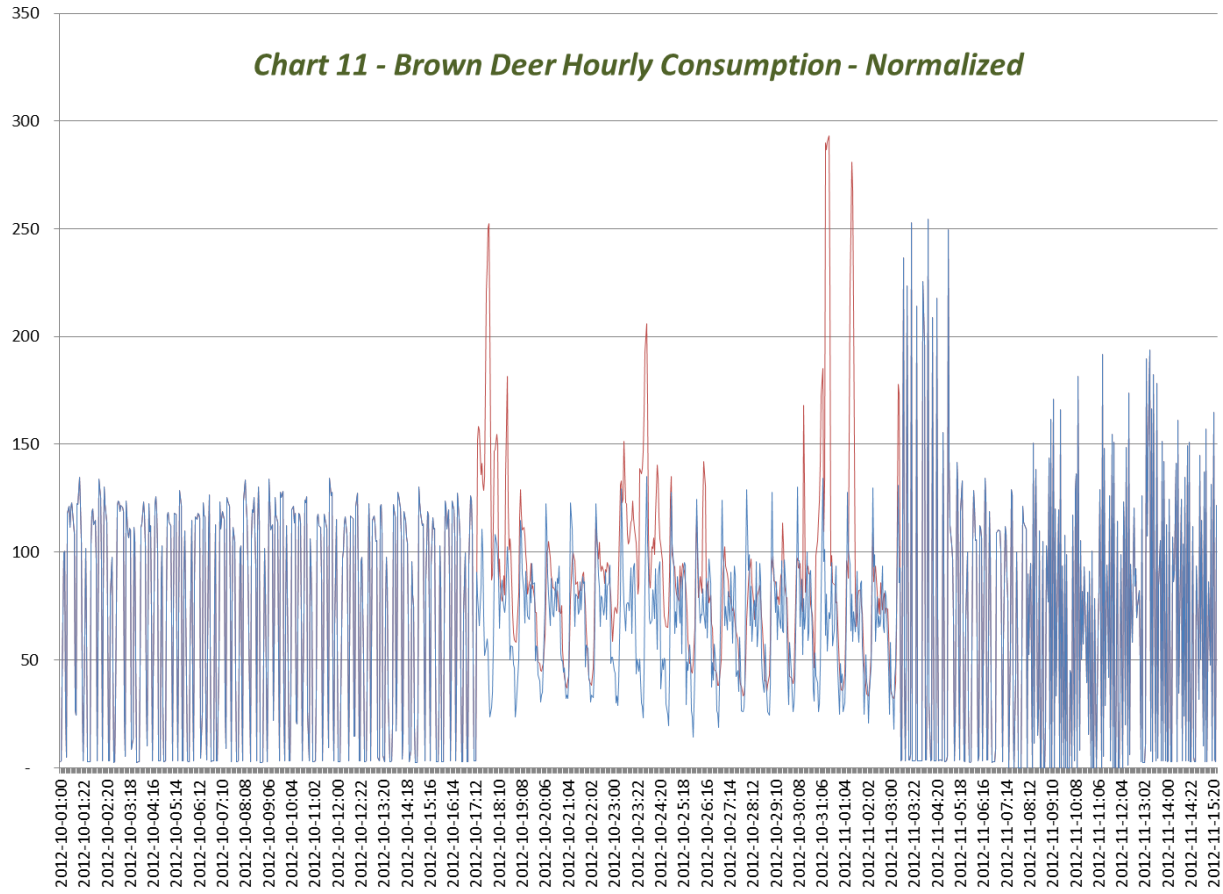


Chart 10 - Brown Deer Daily Consumption - Normalized
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
4/27/2012
5/27/2012
6/27/2012
7/27/2012
8/27/2012
9/27/2012
10/27/2012
11/27/2012
12/27/2012
1/27/2013
2/27/2013
3/27/2013
4/27/2013
5/27/2013
6/27/2013
7/27/2013
8/27/2013
9/27/2013
10/27/2013



Village of Butler

The graphical daily consumption data (Charts 12 and 13) reveals that pumpage for the Village of Butler does not show a great seasonal variation, although it varies significantly from day to day. Its peak daily consumption for the entire period occurred on 7/14/2013, with its peak in 2012 (with only slightly less total pumpage) occurring on 7/11/2012. Hourly pumpage patterns show similar characteristics, with high variability from hour to hour, but little variation in peak hour pumpage in any given day or month. The greatest peak hours occurred on 5/23/2012 and 4/4/2013.

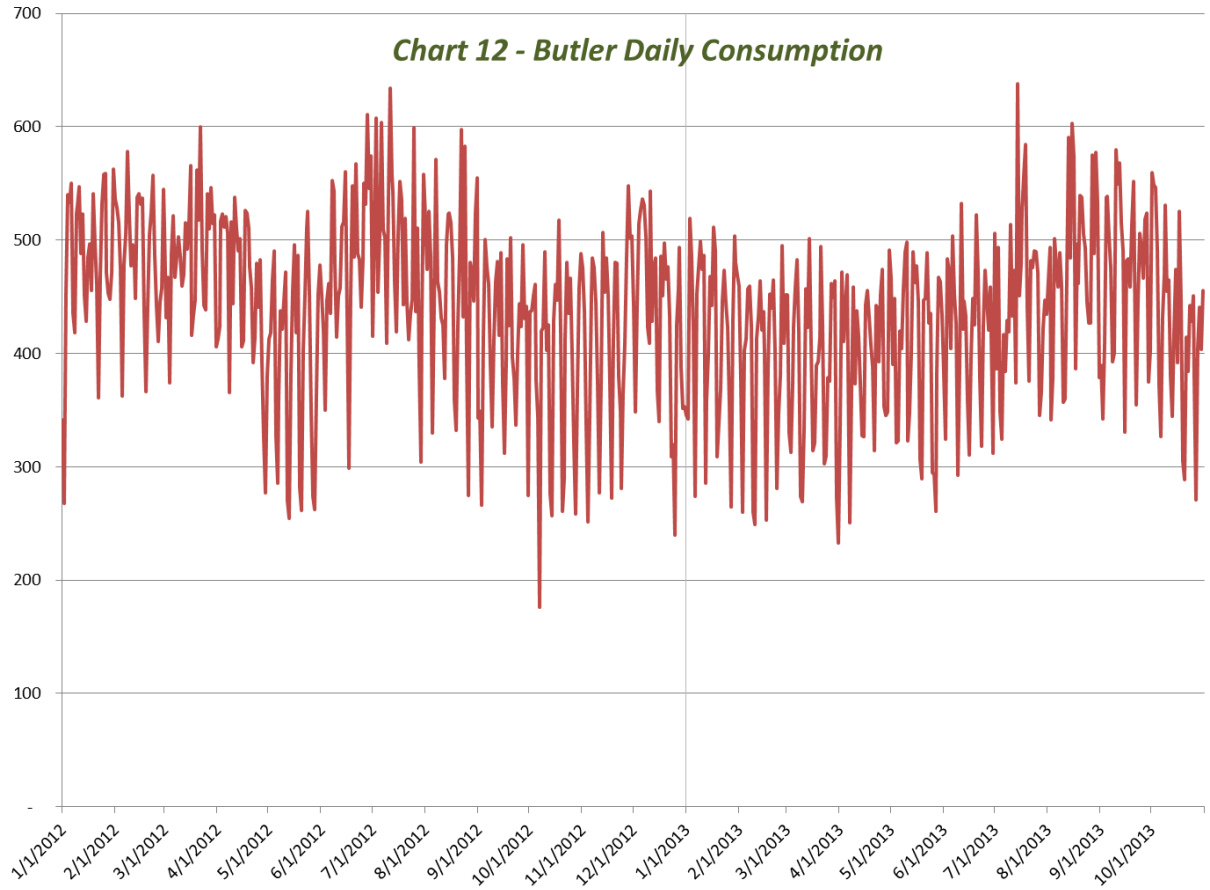
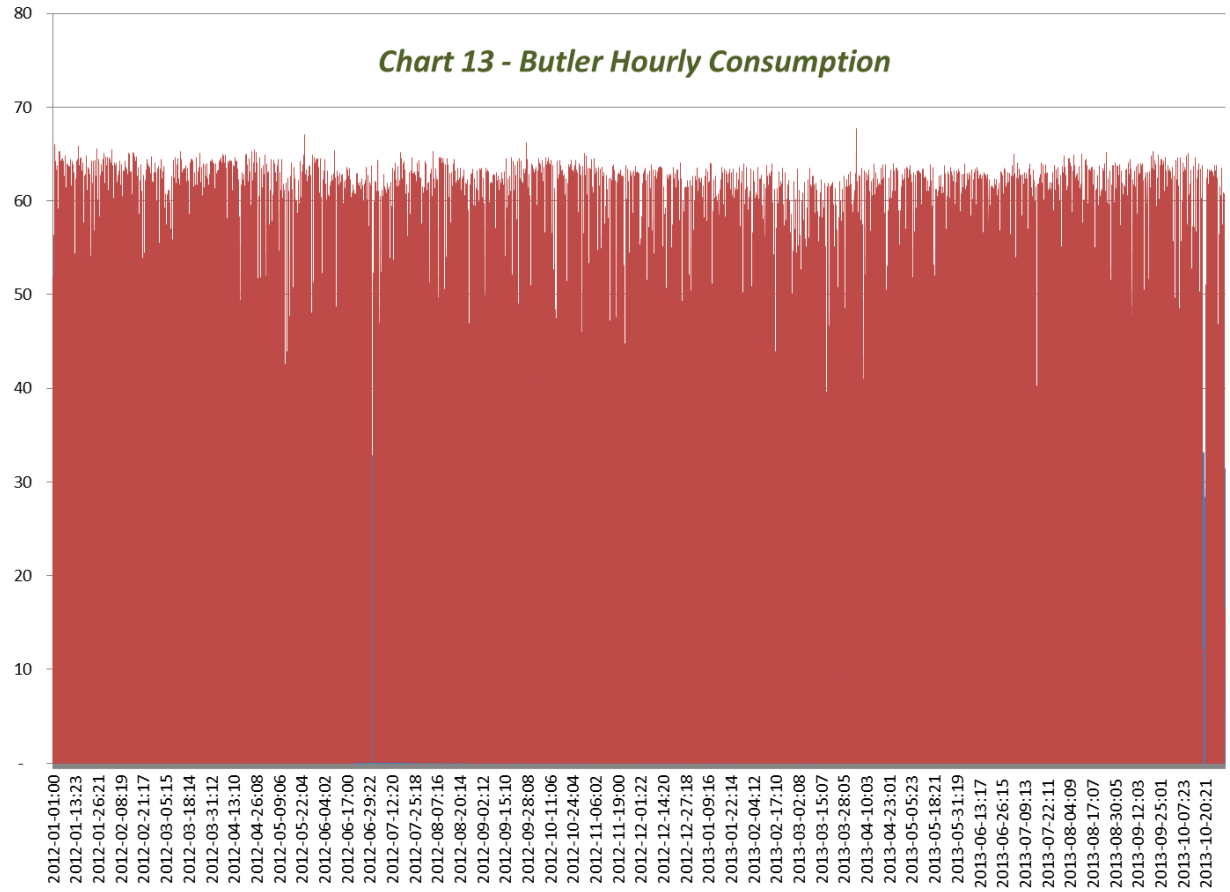


Chart 12 - Butler Daily Consumption
700
600
500
400
300
200
100
-
1/1/2012
2/1/2012
3/1/2012
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
11/1/2012
12/1/2012
1/1/2013
2/1/2013
3/1/2013
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013



Village of Greendale

Greendale's daily and hourly pumpage data are shown in Charts 14 and 15, beginning with 1/1/2012. Data show patterns of high peak usage during the summer seasons, although there is a great deal of variability on a day-to-day basis. Peak daily pumpage occurred on 7/16/2012, with peak 2013 consumption occurring exactly one year later, on 7/16/2013. Hourly data show similar characteristics, with peak hour pumpage occurring during hour 21 on 7/16/2012, although peak hour pumpage in 2013 occurred on 9/23/2013. Additionally, Greendale hourly patterns exhibit a high peak consumption within each day.

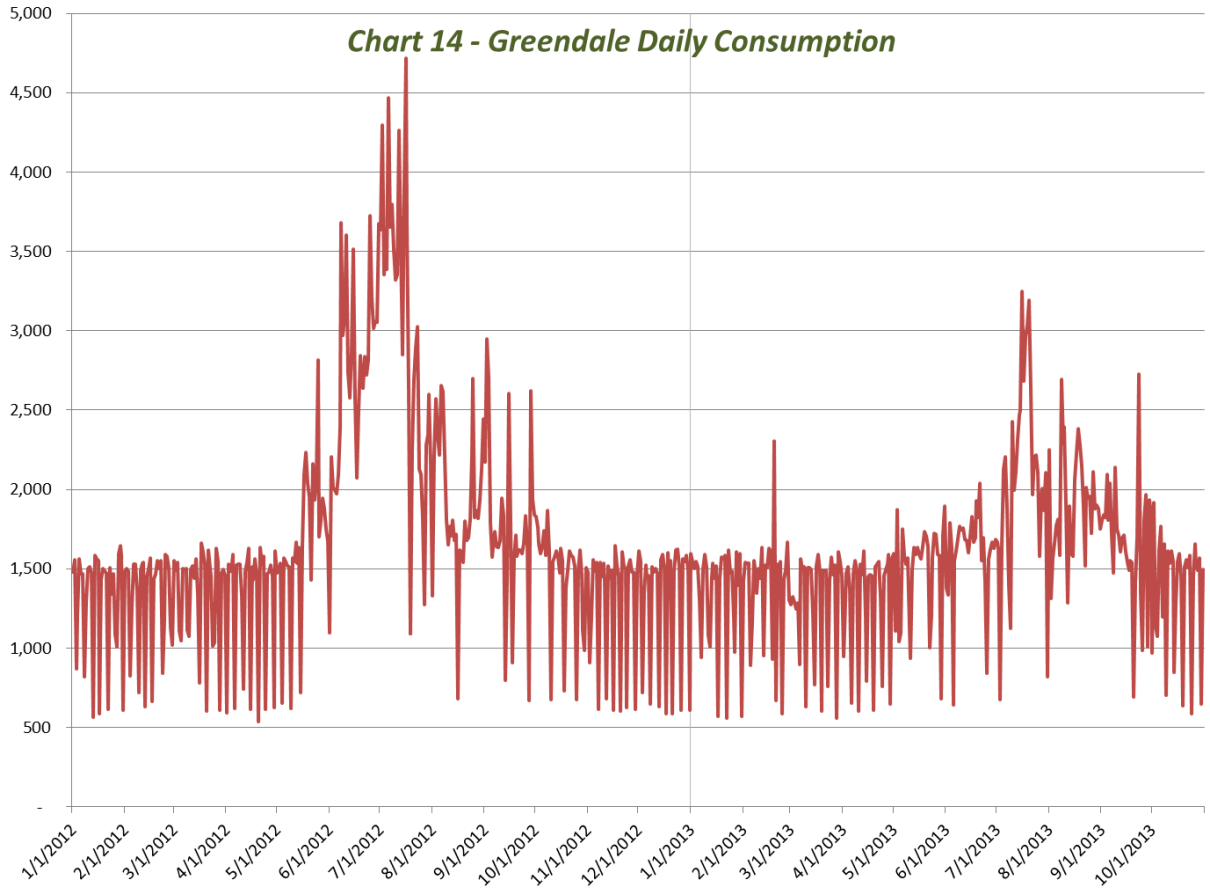
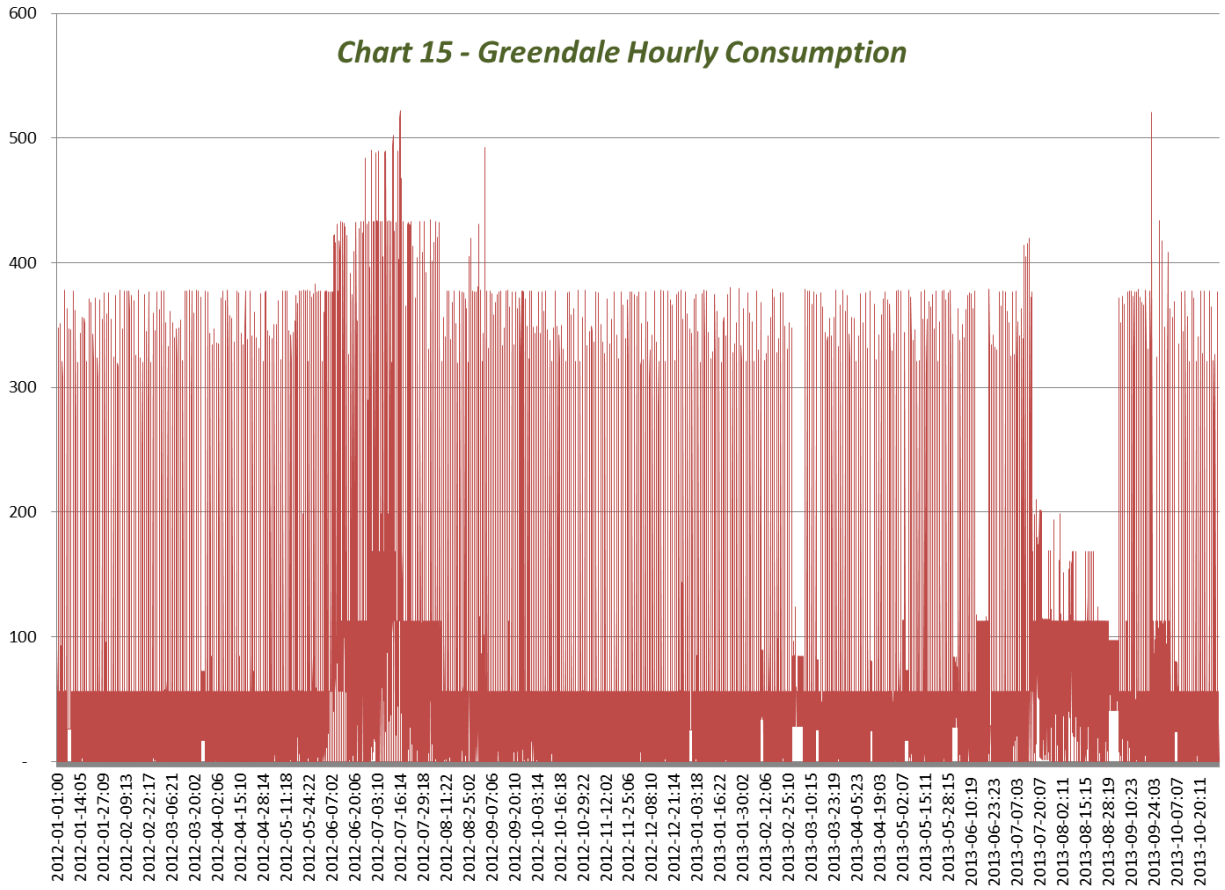
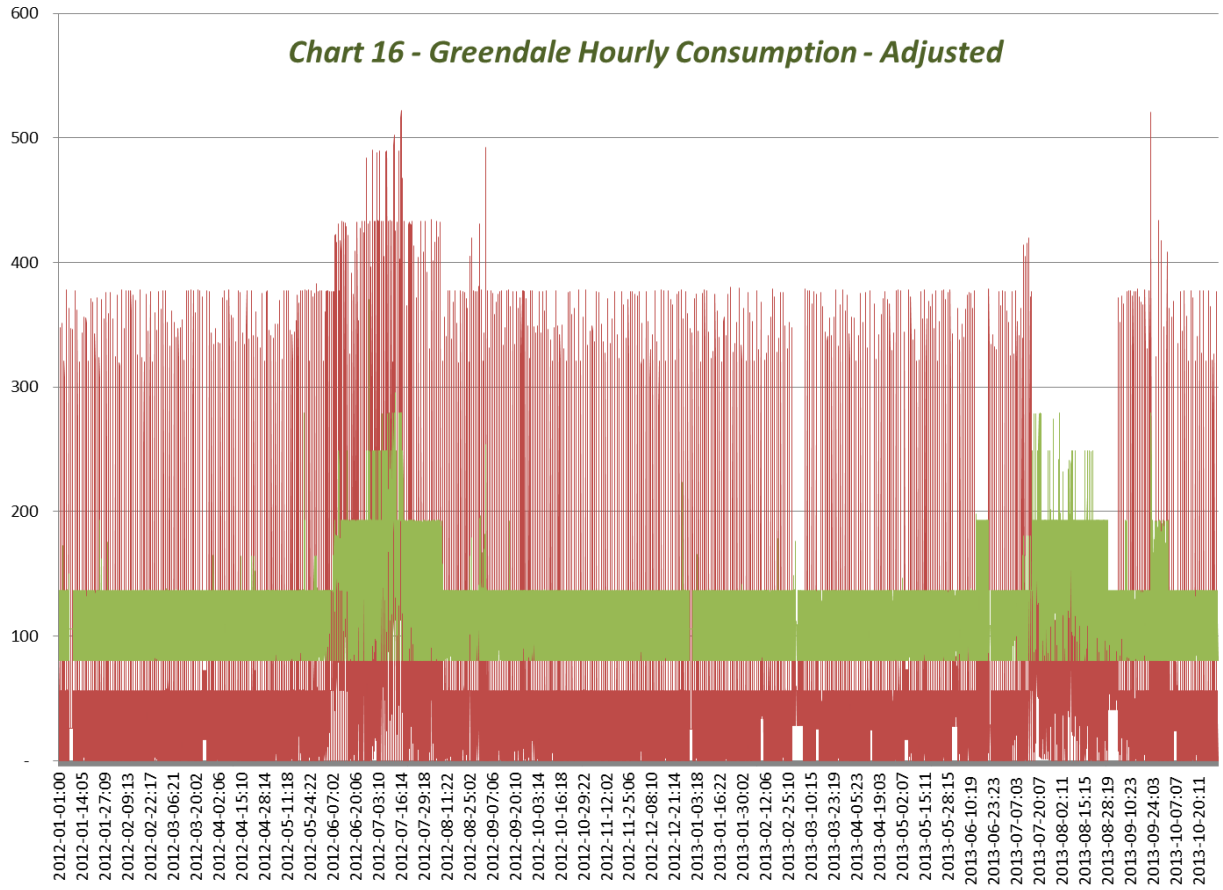


Chart 14 - Greendale Daily Consumption
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
1/1/2012
2/1/2012
3/1/2012
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
11/1/2012
12/1/2012
1/1/2013
2/1/2013
3/1/2013
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013



Data Adjustments

After speaking with the Greendale Village Manager and the water utility's consulting engineer, it was learned that the reason for the high peak hourly usage and hourly demand patterns was the method of operation for filling storage tanks that are then used to satisfy demand throughout each day. However, it was learned that it is possible to alter the pumping rate at the metering point where these tanks are filled which would result in decreased hourly pumpage without changing overall demand. It was demonstrated that this was possible as there was a period of time during 2013 where this metering point was not used, and the remaining connections to the Village increased their usage, but with much different, more stable pumping patterns exhibited. As their operation could be changed going forward, it was decided that it would be appropriate to adjust the data for the entire time period to determine what peak usage would have been had they operated differently during that time. The following chart shows the adjusted hourly peaks overlaid on the original data, assuming that all pumps would have been in operation during any given hour. Daily peaking would not be affected by the change, so no additional analysis was performed for daily usage. As shown in Chart 16, this adjustment significantly reduces peak hour usage. Early data returns in 2014 indicate that the Village has changed their operation as discussed, and that estimated adjusted hourly usage for past data is reasonable.



Village of Menomonee Falls

Data is shown for the Village of Menomonee Falls beginning on 1/2/2012 in Charts 17 and 18. Daily pumpage patterns are very similar to those of Greendale, although with less variability from day to day. Peak pumpage for the entire period occurred on 6/28/2012, with peak pumpage during 2013 occurring on 8/27/2013. There was a secondary period of peak pumpage during 2013 around 7/18/2013. Hourly data show similar patterns, although there are many hours throughout the year that have are at or near the peak hourly pumpage overall. For the entire period, peak hourly pumpage occurred during hour 1 on 5/15/2012. 2013 peak hourly pumpage occurred on 8/27/2013. Additional hours of near peak demand occurred during January, June, July and October of 2012 and June, July, August and September of 2013.

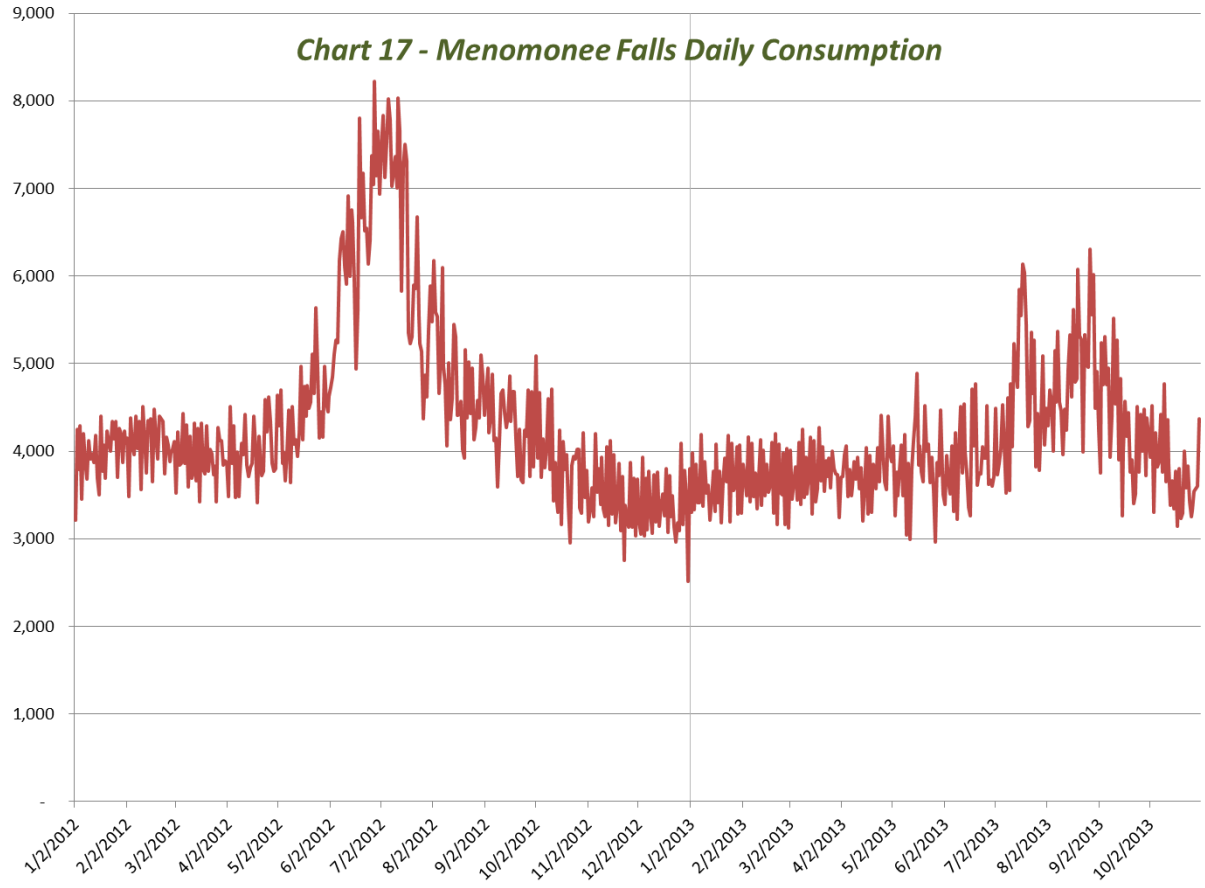
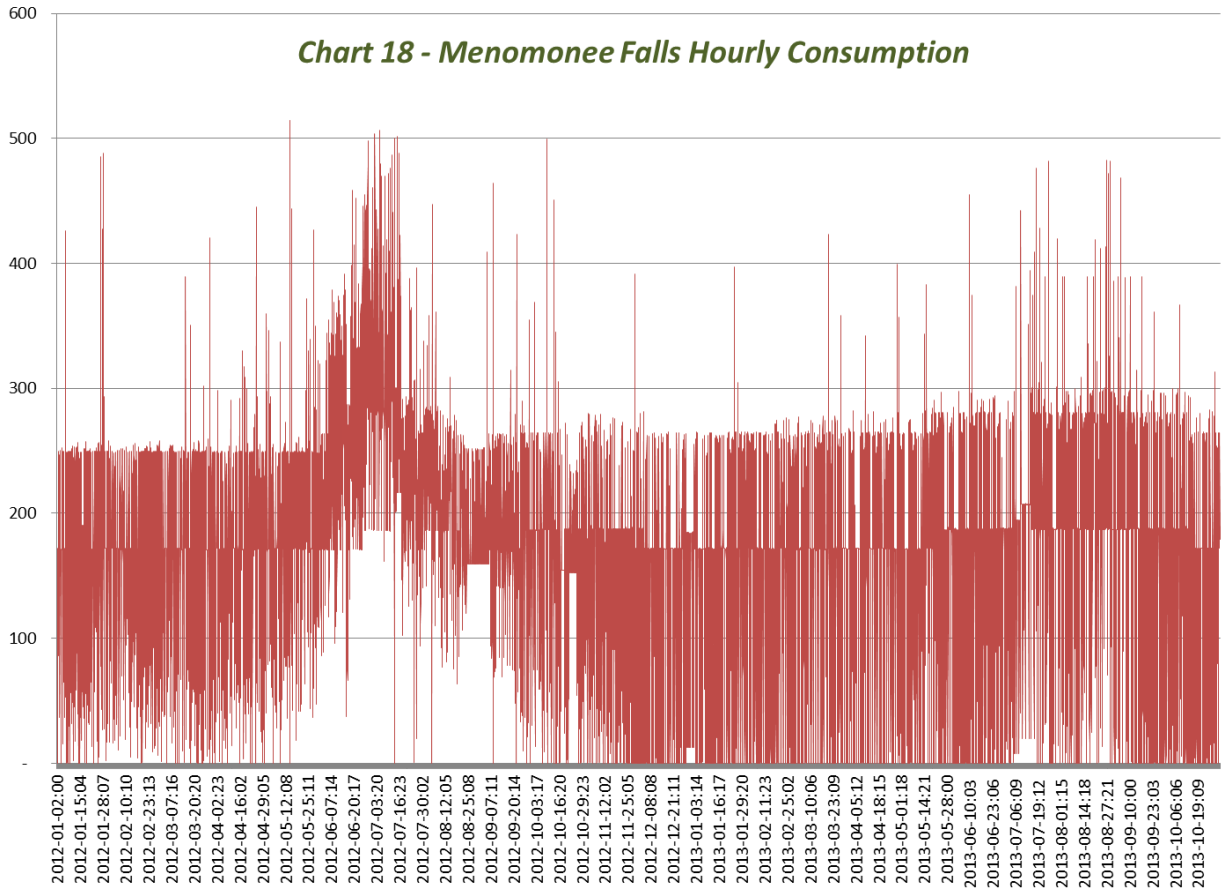


Chart 17 - Menomonee Falls Daily Consumption
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
1/2/2012
2/2/2012
3/2/2012
4/2/2012
5/2/2012
6/2/2012
7/2/2012
8/2/2012
9/2/2012
10/2/2012
11/2/2012
12/2/2012
1/2/2013
2/2/2013
3/2/2013
4/2/2013
5/2/2013
6/2/2013
7/2/2013
8/2/2013
9/2/2013
10/2/2013



City of Mequon

Data is shown for Mequon starting on 6/14/2012 in Charts 19 and 20. The solid horizontal line from October 2012 to April 2013 represents a lengthy period of time where the hourly pumpage was not reading, although the meter itself was still recording how much water was used. The line shown on the chart is the average of all daily water usage during that period, so that total and average usage is accurate. After speaking with Mequon officials and the utility operator, Mequon's own data was received and reviewed, and it was confirmed that the average usage during this time was accurate, with no peak day event occurring during that timeframe. Peak recorded daily pumpage during the entire period occurred on 7/2/2012, with peak 2013 daily pumpage occurring on 8/27/2013. Hourly pumpage patterns track very closely with daily patterns, with the exception of the peak hourly usage for the period, which occurs during hour 9 on 7/12/2013. During July 2012, there are a number of hours which show about the same peak usage.

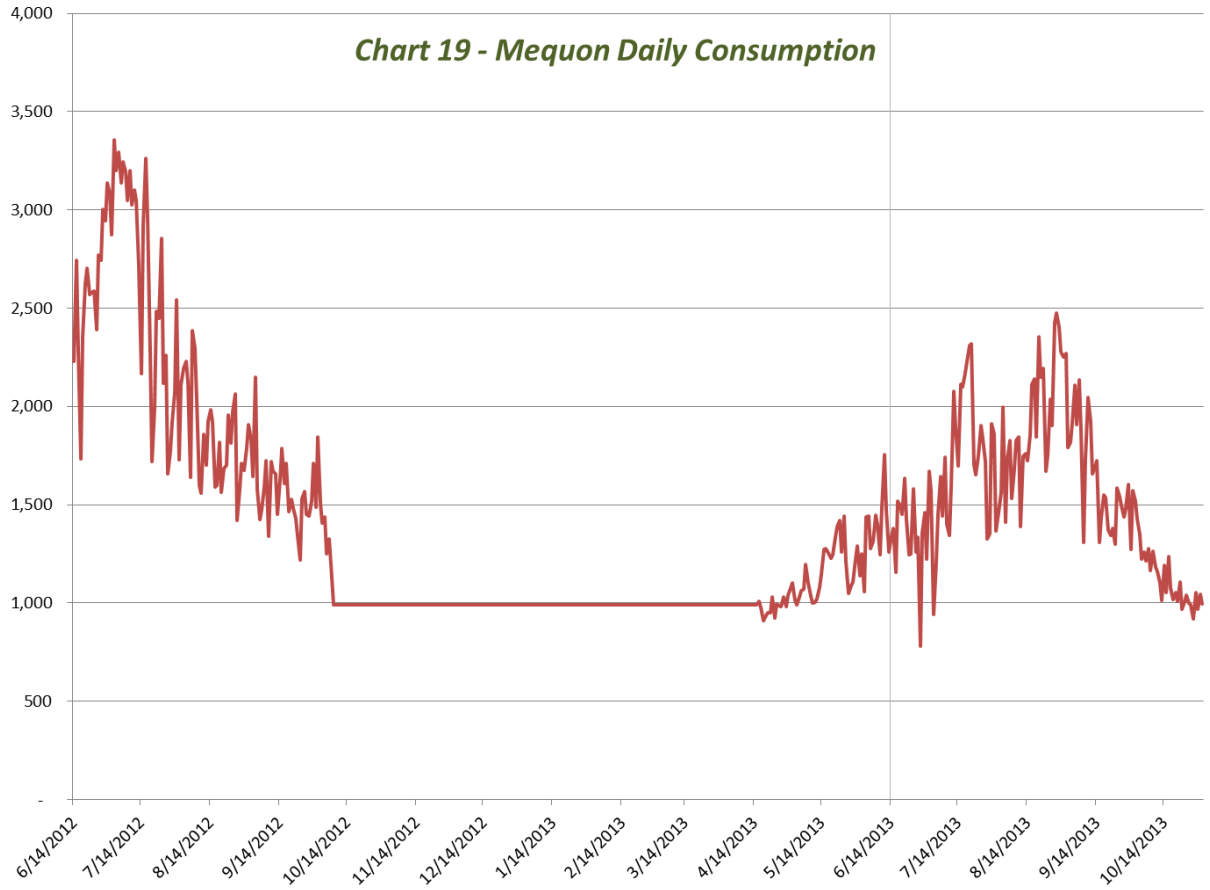
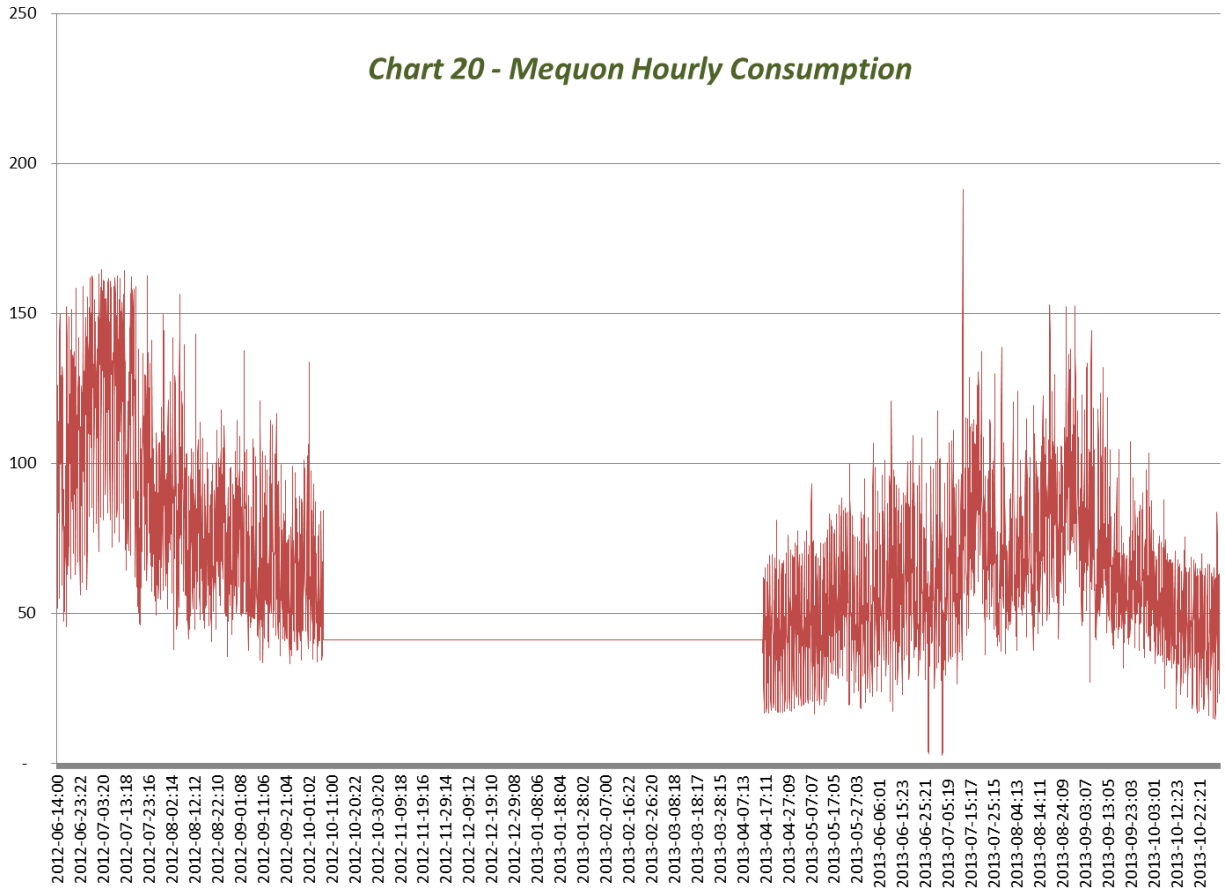


Chart 19 - Mequon Daily Consumption
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
6/14/2012
7/14/2012
8/14/2012
9/14/2012
10/14/2012
11/14/2012
12/14/2012
1/14/2013
2/14/2013
3/14/2013
4/14/2013
5/14/2013
6/14/2013
7/14/2013
8/14/2013
9/14/2013
10/14/2013



City of New Berlin

New Berlin pumpage data exhibit relatively typical pumpage patterns, beginning on 1/4/2012, shown in Charts 21 and 22. Overall peak daily pumpage occurred on 7/6/2012 and peak daily pumpage for 2013 occurred the following July on 7/17/2013. Interestingly, the peak hour of pumpage for the entire period occurs during hour 18 on 1/6/2012. After that day, there are a number of peak hours on different days during the period that approximately the same; these occur during June, July, August, September and December of 2012 and January, March and July of 2013. As the graphs show, not all of these days coincide with peak days of pumpage.

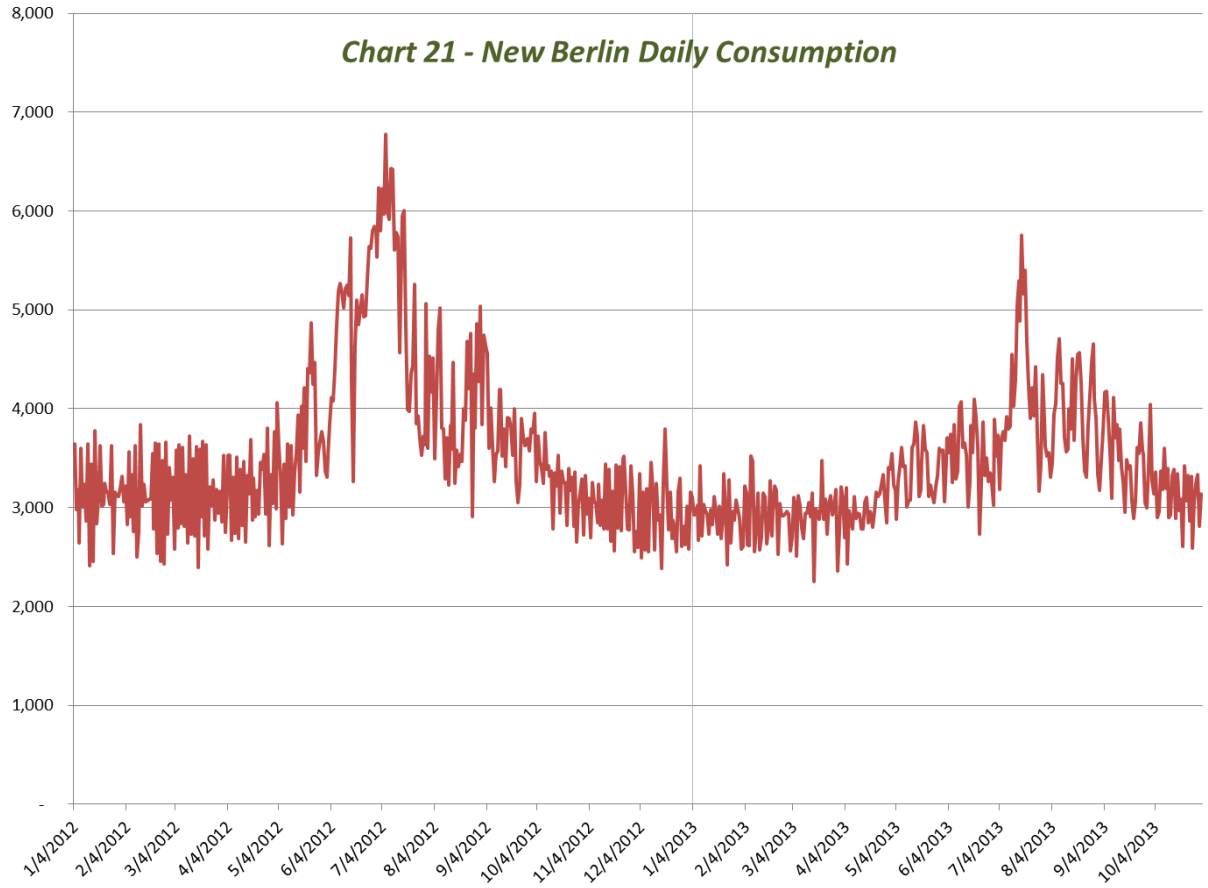
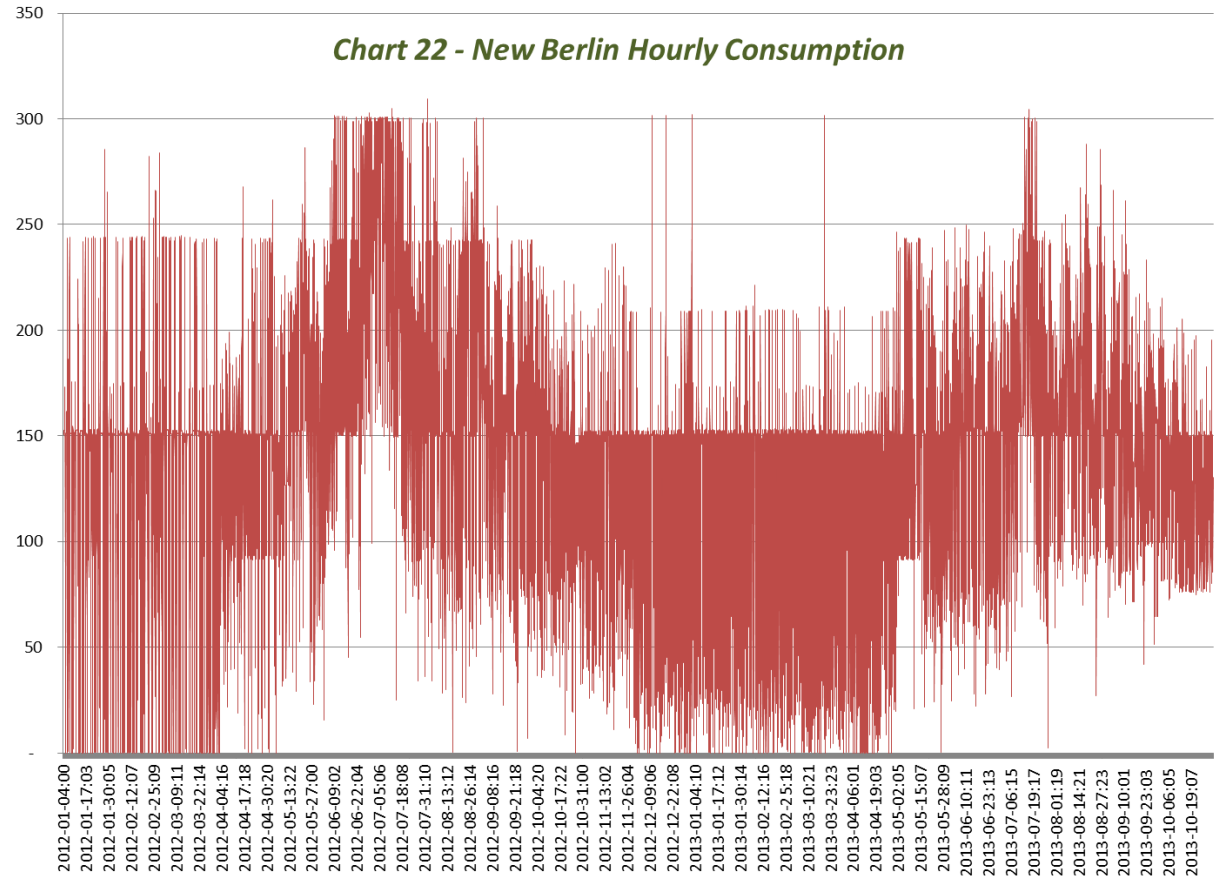


Chart 21 - New Berlin Daily Consumption
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
1/4/2012
2/4/2012
3/4/2012
4/4/2012
5/4/2012
6/4/2012
7/4/2012
8/4/2012
9/4/2012
10/4/2012
11/4/2012
12/4/2012
1/4/2013
2/4/2013
3/4/2013
4/4/2013
5/4/2013
6/4/2013
7/4/2013
8/4/2013
9/4/2013
10/4/2013



City of Wauwatosa

Data was available for the City of Wauwatosa beginning on 5/10/2012, shown in Charts 23 and 24. The day of highest peak usage for the entire period occurred on 7/6/2012. During 2013, there were two smaller peaks of similar magnitude: 7/18/2013 and 8/21/2013. The graph showing hourly consumption indicates greater variability from hour to hour, but also shows less of a seasonal effect of peak hours throughout the year. The hour of peak consumption for the entire period occurred during hour 20 on 7/16/2012, although there were several hours of high demand intermittently throughout the period. During 2013, the peak hour of demand occurred on 7/20/2013.

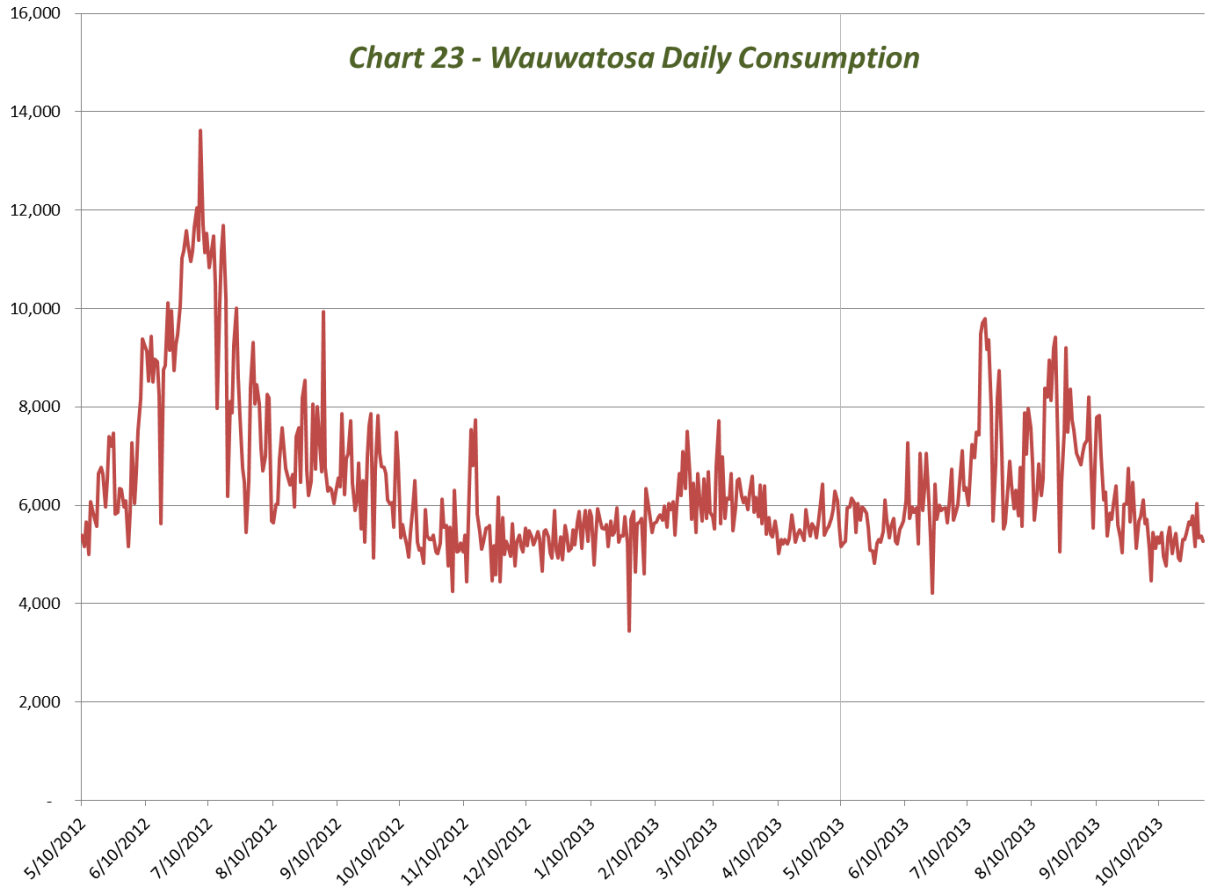
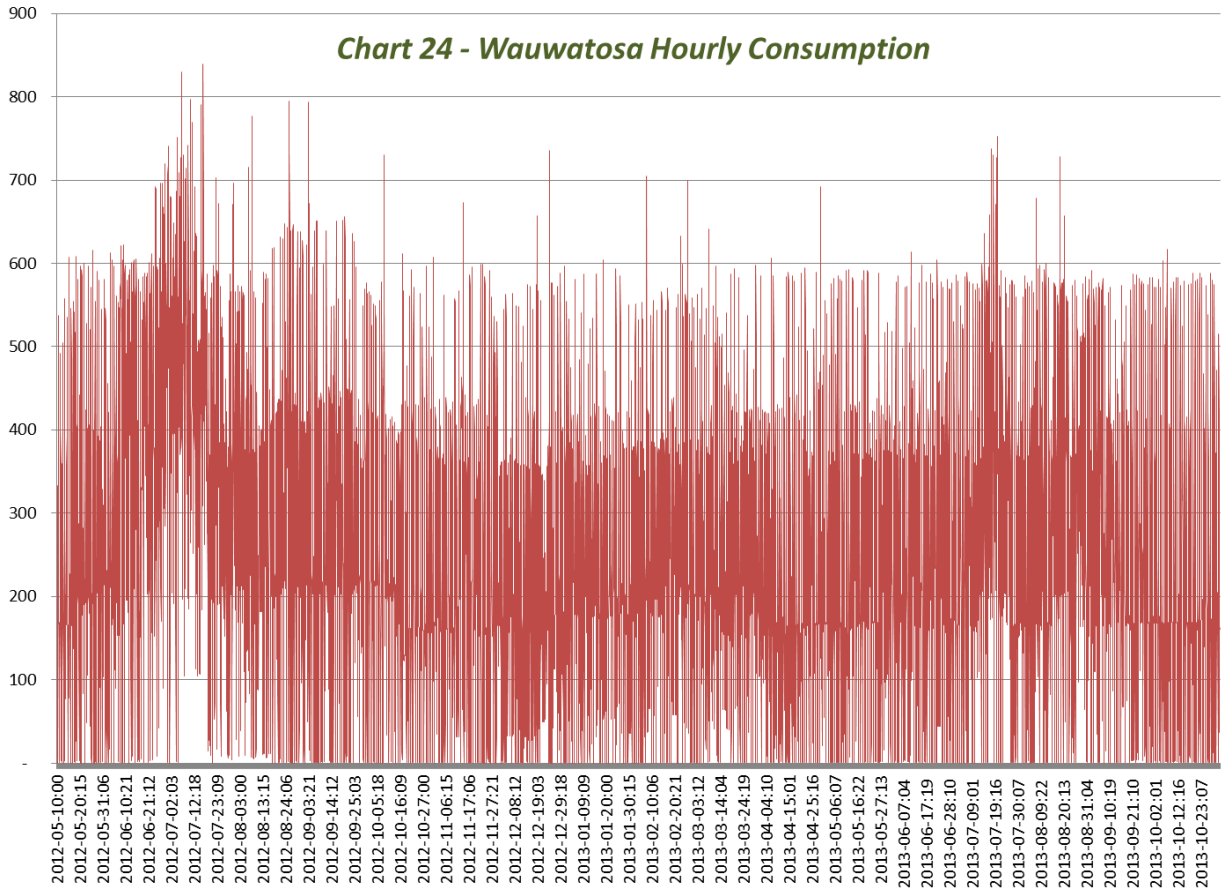


Chart 23 - Wauwatosa Daily Consumption
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
5/10/2012
6/10/2012
7/10/2012
8/10/2012
9/10/2012
10/10/2012
11/10/2012
12/10/2012
1/10/2013
2/10/2013
3/10/2013
4/10/2013
5/10/2013
6/10/2013
7/10/2013
8/10/2013
9/10/2013
10/10/2013



City of West Allis

West Allis has data available beginning on 3/22/2012, shown in Charts 25 and 26. Peak daily consumption for the entire period of analysis occurred on 7/17/2012. During 2013, there were two days of peak days of nearly the same magnitude: 7/16/2013 and 8/8/2013. Considering the clear trend in seasonal usage when looking at daily demand, it is somewhat surprising that hourly usage patterns do not reveal any seasonal component related to peak hour consumption. For the entire period, the hour of peak consumption occurred during hour 8 on 7/12/2013. Beyond that, the peak hour during any given day or month stayed relatively stable; it appears that only the number of those hours of peak usage during each day is the determining factor in total daily usage.

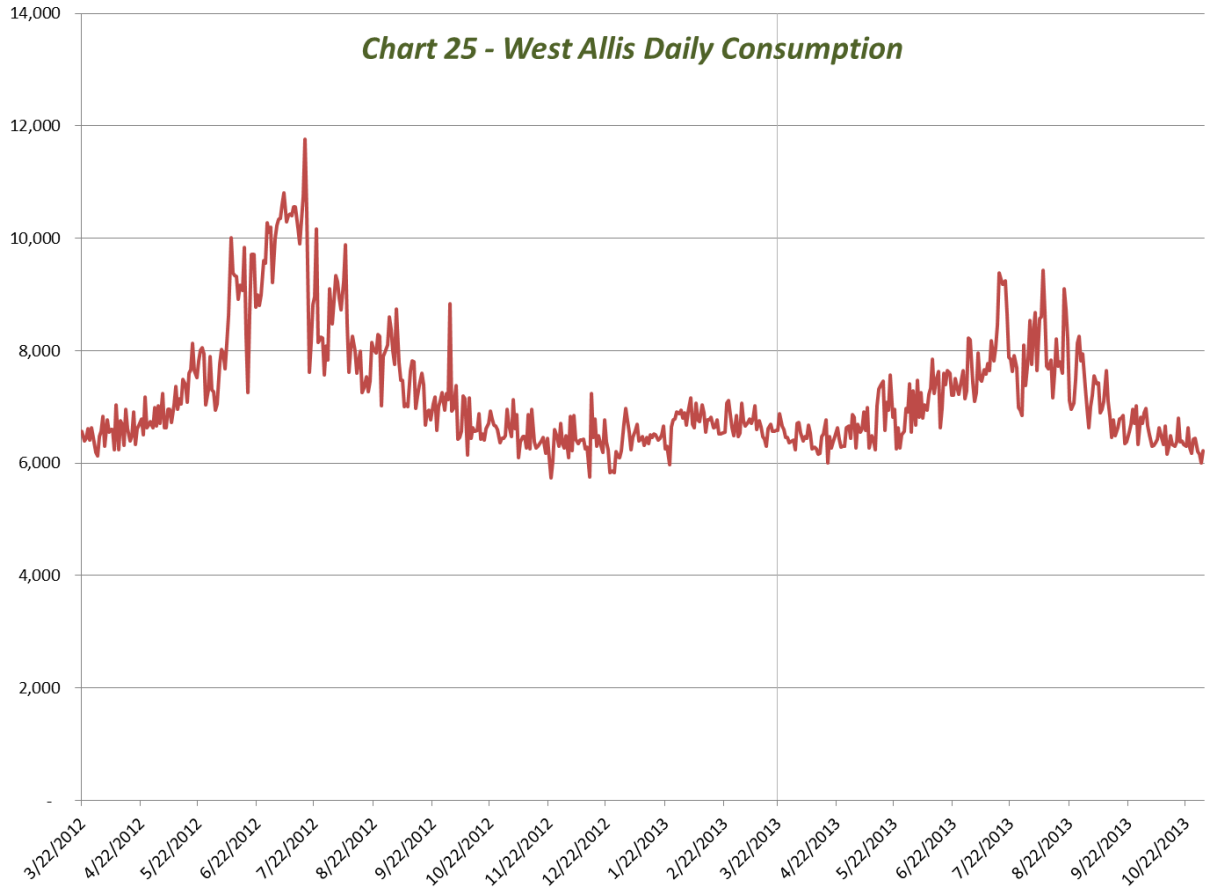
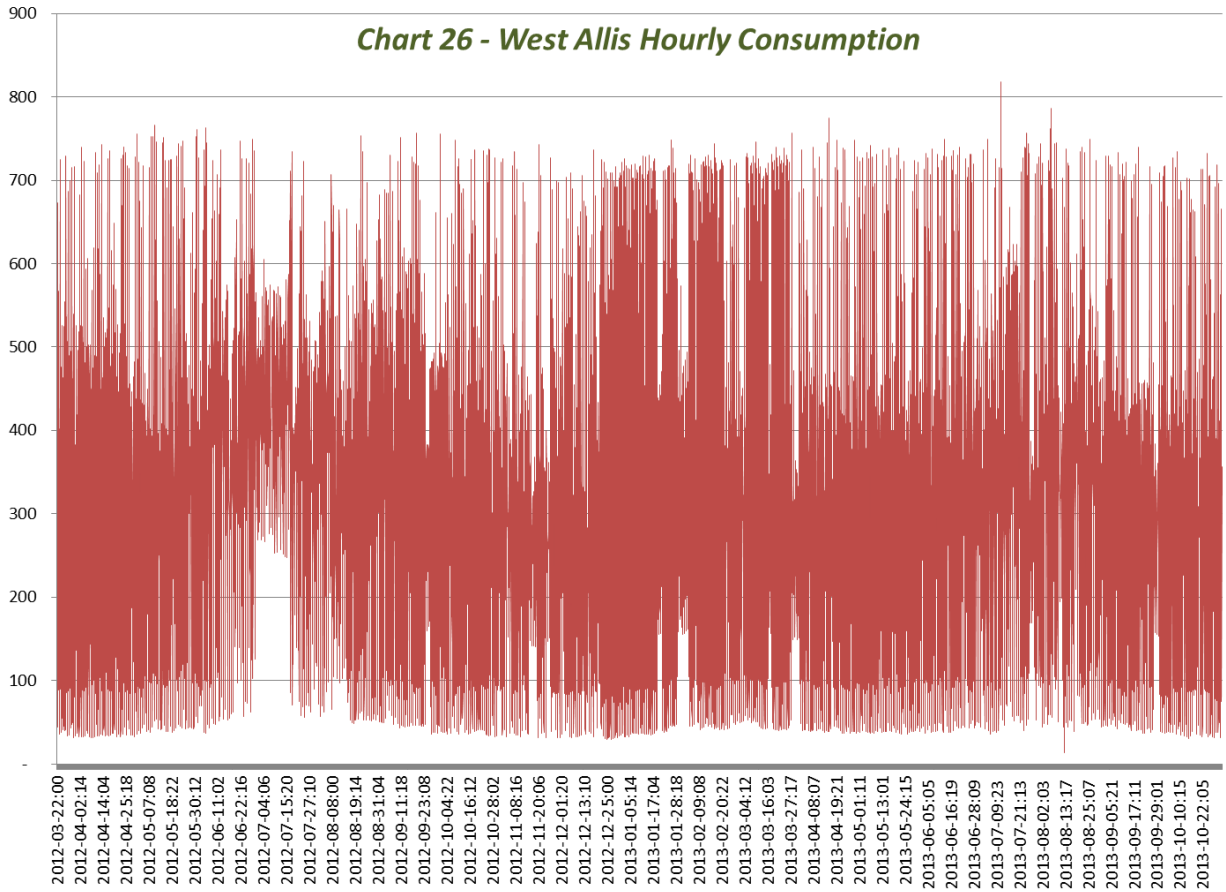


Chart 25 - West Allis Daily Consumption
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
3/22/2012
4/22/2012
5/22/2012
6/22/2012
7/22/2012
8/22/2012
9/22/2012
10/22/2012
11/22/2012
12/22/2012
1/22/2013
2/22/2013
3/22/2013
4/22/2013
5/22/2013
6/22/2013
7/22/2013
8/22/2013
9/22/2013
10/22/2013



Village of Shorewood

At the time of the analysis, there was not currently a meter installed for the Village of Shorewood that had the ability to provide the same level of precision down to each hour as most of the other wholesale customers. In order to determine appropriate peak ratios for Shorewood, another analytical method used data that is known from the other wholesale customers. This is addressed in the next part of this section.

Milwaukee County Grounds

There is not currently a meter installed at the Milwaukee County Grounds to measure water pumpage to the hourly level. However, the internal customers consist mainly of users that would be classified as commercial (hospitals, offices, etc.). For this reason, it is reasonable to assume that collectively, they exhibit similar peak demand patterns as Milwaukee's retail commercial customer base and should be assigned the same peaking factors as the urban retail commercial customer class.

Summary

One thing to note about hourly pumpage data for wholesale customers in general: it is clear that each customer's utility operation has a great impact on its peak usage characteristics. Differences in flow

rates at metering points with Milwaukee, their own internal customer makeup, and their use of internal storage to meet peak hour demand affect their supply side pumpage and are, therefore, reflected in the data and the resulting peak hour (and in some cases, peak day) ratios. What this study is determining is the appropriate peaking ratio for each wholesale customer, which is determined by pumpage at the metering point(s) of each customer. No consideration should be or is given to pumpage rates within the customer's own water distribution system.

ANALYSIS OF WHOLESALE PEAK RATIOS

The next step in the analysis is to translate the raw data into ratios of peak-to-average daily pumpage and peak-to-average hourly pumpage. Tables 11 through 18 summarize the data, showing, for each wholesale customer, total monthly pumpage, maximum daily pumpage during each month and maximum hourly pumpage during each month, displayed in units of thousands of gallons. The tables begin with the first month in which there is a complete month of reliable data (with the exception of Mequon). The last two columns show a calculation of the ratios of maximum day to average day demand and maximum hour to average day demand for the preceding 12-month period.

The results show a wide range of peak demand ratios, dependent on the customer, the year and the period of analysis during the year. This variation indicates that in order to determine the most reasonable peaking factors for each wholesale customer, an averaging concept is appropriate. This approach considers the effect of yearly weather patterns and other natural fluctuations in demand patterns. With an averaging approach, ideally the analysis would have as many data points as possible for greater accuracy; however, because the data availability is limited, the approach has to be adjusted in a way that the result will reflect the actual average peak demand.

Determination of Proposed Peaking Factors

As the data indicate, maximum demand ratios will fluctuate depending on fluctuations in both the maximum usage and the average day usage. Maximum and average usage will fluctuate based on weather, other underlying demand trends and the period of time during which the ratios are calculated. As more data is collected, hypothetically a customer's peaking ratios would bounce around a number that would be its natural average. However, as there was a limited timeframe in which to collect and analyze data, this analysis had to take a closer look at the results to determine a method to reasonably estimate the average peak demand of each wholesale customer that would consider both seasonal (weather-related) fluctuations and fluctuations caused by time period selection.

If enough data were available, a simple average of all of the calculated previous 12 months ratios would be sufficient to determine each customer's average peak demand ratios. However, a simple average would not work with the number of data points in this analysis because the uneven number of points based on the 2012 peak event(s) versus the 2013 peak event(s) would skew the calculated number either high or low. To correct for this, the analysis first averages the group of peak ratios associated with each distinct peak event and then calculates the average of all of the distinct peak events.

The figures used for this analysis are shown in each table within the last two columns. For each column, first the ratios within each outlined box are averaged, then the results of each of those calculations are averaged, with the resulting figure being the proposed peak ratio and corresponding extra capacity

factor for each customer. For example, for Brown Deer, below, there are 2 distinct peak days, as outlined in red. There are different 12-month periods that correspond to each peak event – these are the calculated ratios shown in the last 2 columns. One can see that there is a significant shift in the ratios when calculating peak ratios using different peak events; however, there is also fluctuation within each peak – this is due to fluctuation in average demand.

Table 11 - Brown Deer Peak Ratio Analysis

	Brown Deer Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-May	44,056	1,882	211		
12-Jun	58,709	2,586	206		
12-Jul	66,740	2,819	207		
12-Aug	50,063	2,048	207		
12-Sep	42,091	1,610	129		
12-Oct	38,763	1,450	101		
12-Nov	33,884	1,474	190		
12-Dec	34,068	1,222	151		
13-Jan	36,312	1,522	165		
13-Feb	32,452	1,542	149		
13-Mar	35,408	1,304	156		
13-Apr	34,713	1,832	190	2.03	3.64
13-May	37,741	1,387	177	2.05	3.62
13-Jun	38,564	1,651	177	2.14	3.78
13-Jul	44,896	1,914	129	1.63	3.95
13-Aug	46,134	1,896	180	1.54	3.67
13-Sep	39,980	1,552	218	1.54	4.22
13-Oct	36,120	1,308	171	1.55	4.24
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.82**	**3.88**
Extra Capacity Factors				**0.82**	**2.88**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.89	1.71

Table 12 - Butler Peak Ratio Analysis

	Butler Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Jan	11,110	421	49		
12-Feb	10,596	433	49		
12-Mar	11,327	449	49		
12-Apr	10,231	402	49		
12-May	9,250	393	50		
12-Jun	10,878	457	49		
12-Jul	11,360	475	49		
12-Aug	10,777	447	49		
12-Sep	9,207	376	50		
12-Oct	9,192	387	49		
12-Nov	9,323	410	48		
12-Dec	10,069	406	48	1.41	3.58
13-Jan	9,754	389	48	1.42	3.62
13-Feb	8,298	370	48	1.45	3.67
13-Mar	8,916	375	48	1.48	3.75
13-Apr	8,944	367	51	1.49	3.83
13-May	9,427	373	48	1.49	3.82
13-Jun	9,350	398	48	1.51	3.87
13-Jul	10,455	477	49	1.53	3.90
13-Aug	11,048	451	49	1.53	3.89
13-Sep	10,477	434	49	1.51	3.85
13-Oct	9,910	419	49	1.50	3.83
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.49**	**3.75**
Extra Capacity Factors				**0.49**	**2.75**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.63	1.33

Table 13 - Greendale Peak Ratio Analysis

	Greendale Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos. - M2
12-Jan	30,239	1,232	144		
12-Feb	28,732	1,189	103		
12-Mar	31,296	1,242	123		
12-Apr	29,372	1,222	123		
12-May	38,686	2,106	209		
12-Jun	61,478	2,785	277		
12-Jul	70,703	3,529	221		
12-Aug	44,638	2,021	147		
12-Sep	39,507	2,206	190		
12-Oct	34,164	1,399	103		
12-Nov	29,203	1,230	102		
12-Dec	30,665	1,213	167	2.76	5.19
13-Jan	31,255	1,209	124	2.75	5.18
13-Feb	29,327	1,724	133	2.74	5.16
13-Mar	30,362	1,201	132	2.74	5.17
13-Apr	28,958	1,206	102	2.75	5.17
13-May	34,507	1,420	110	2.77	5.22
13-Jun	36,090	1,526	148	2.93	4.41
13-Jul	48,452	2,430	157	2.13	3.98
13-Aug	44,343	2,014	149	2.13	3.99
13-Sep	37,672	2,039	209	2.14	4.41
13-Oct	31,632	1,435	144	2.15	4.44
13-Nov					
13-Dec					
Calculated Peaking Ratios				**2.46**	**4.49**
Extra Capacity Factors				**1.46**	**3.49**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.93	1.76

Table 14 - Menomonee Falls Peak Ratio Analysis

	Menomonee Falls Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Jan	92,559	3,291	365		
12-Feb	88,997	3,376	193		
12-Mar	91,398	3,311	314		
12-Apr	88,978	3,457	333		
12-May	102,675	4,218	385		
12-Jun	140,925	6,152	373		
12-Jul	149,734	6,006	379		
12-Aug	111,988	4,624	334		
12-Sep	96,664	3,702	347		
12-Oct	90,119	3,805	374		
12-Nov	78,250	3,139	293		
12-Dec	78,174	3,057	211	1.86	2.79
13-Jan	84,584	3,133	297	1.87	2.81
13-Feb	77,304	3,142	207	1.89	2.83
13-Mar	86,454	3,192	316	1.89	2.84
13-Apr	84,489	3,302	299	1.90	2.85
13-May	88,933	3,658	287	1.92	2.84
13-Jun	86,699	3,564	340	1.97	2.98
13-Jul	106,452	4,593	360	1.58	3.06
13-Aug	113,816	4,714	361	1.61	3.05
13-Sep	96,981	4,128	350	1.60	3.05
13-Oct	87,361	3,564	274	1.61	2.96
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.75**	**2.95**
Extra Capacity Factors				**0.75**	**1.95**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.64	1.35

Table 15 - Mequon Peak Ratio Analysis

	Mequon Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Jul	61,047	2,510	123		
12-Aug	42,924	1,785	117		
12-Sep	35,260	1,607	103		
12-Oct	25,200	1,379	100		
12-Nov	22,182	739	31		
12-Dec	22,921	739	31	2.12	2.48
13-Jan	22,921	739	31		
13-Feb	20,703	739	31		
13-Mar	22,921	739	31		
13-Apr	22,132	803	61		
13-May	26,987	1,080	75		
13-Jun	30,444	1,314	90	2.58	3.03
13-Jul	39,850	1,734	143	1.95	3.75
13-Aug	44,585	1,852	114	2.01	3.73
13-Sep	36,524	1,598	108	2.00	3.72
13-Oct	26,074	1,137	77	2.00	3.71
13-Nov					
13-Dec					

Calculated Peaking Ratios	**2.23**	**3.08**
Extra Capacity Factors	**1.23**	**2.08**

Based on 2012 PSC Report

Based on daily average due to data transmission freeze

2011 PSC Final Cost-of-Service		
Extra Capacity Factors	1.13	2.05

Table 16 - New Berlin Peak Ratio Analysis

	New Berlin Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Feb	67,749	2,873	212		
12-Mar	72,226	2,789	183		
12-Apr	71,212	2,843	201		
12-May	84,473	3,641	214		
12-Jun	109,446	4,369	226		
12-Jul	118,079	5,067	228		
12-Aug	93,046	3,769	232		
12-Sep	84,668	3,547	225		
12-Oct	75,921	2,957	182		
12-Nov	68,402	2,631	180		
12-Dec	67,972	2,842	226		
13-Jan	67,988	2,563	226	1.89	2.07
13-Feb	61,258	2,635	166	1.90	2.08
13-Mar	67,422	2,597	226	1.91	2.09
13-Apr	67,365	2,545	158	1.91	2.10
13-May	78,203	2,896	185	1.93	2.11
13-Jun	78,404	3,068	187	1.99	2.18
13-Jul	96,494	4,308	228	1.73	2.24
13-Aug	91,944	3,520	215	1.74	2.20
13-Sep	78,398	3,125	199	1.75	2.22
13-Oct	73,334	3,025	161	1.75	2.22
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.83**	**2.16**
Extra Capacity Factors				**0.83**	**1.16**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.69	1.42

Table 17 - Wauwatosa Peak Ratio Analysis

	Wauwatosa Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Jun	196,020	8,662	554		
12-Jul	225,087	10,194	628		
12-Aug	164,245	6,395	595		
12-Sep	151,368	7,428	594		
12-Oct	132,636	5,605	546		
12-Nov	122,849	5,790	504		
12-Dec	121,461	4,405	550		
13-Jan	126,058	4,449	452		
13-Feb	125,099	5,615	527		
13-Mar	143,003	5,771	479		
13-Apr	124,307	4,797	518		
13-May	130,953	4,816	443	2.11	3.12
13-Jun	130,998	5,442	459	2.19	3.24
13-Jul	165,412	7,326	563	1.65	3.18
13-Aug	168,241	7,046	545	1.65	3.17
13-Sep	142,800	6,137	442	1.64	3.02
13-Oct	124,015	4,569	462	1.65	3.03
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.81**	**3.13**
Extra Capacity Factors				**0.81**	**2.13**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.59	1.28

Table 18 - West Allis Peak Ratio Analysis

	West Allis Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Apr	148,989	5,366	556		
12-May	169,454	6,085	573		
12-Jun	200,780	7,687	571		
12-Jul	222,732	8,799	550		
12-Aug	189,638	7,394	564		
12-Sep	163,699	6,539	566		
12-Oct	156,550	6,611	566		
12-Nov	144,230	5,327	556		
12-Dec	147,192	5,417	551		
13-Jan	151,753	5,219	560		
13-Feb	141,741	5,355	557		
13-Mar	153,146	5,285	566	1.61	2.52
13-Apr	144,722	5,138	579	1.62	2.56
13-May	157,081	5,663	555	1.63	2.57
13-Jun	163,943	6,154	561	1.66	2.62
13-Jul	183,202	7,015	612	1.42	2.83
13-Aug	184,559	7,053	588	1.36	2.83
13-Sep	154,063	5,722	554	1.37	2.85
13-Oct	148,356	5,213	549	1.37	2.86
13-Nov					
13-Dec					
Calculated Peaking Ratios				**1.51**	**2.70**
Extra Capacity Factors				**0.51**	**1.70**
2011 PSC Final Cost-of-Service Extra Capacity Factors				0.46	1.09

Customers without Hourly Readings

As previously stated, two wholesale customers have no hourly meter reading data to use to determine extra capacity peaking factors to use in the cost-of-service. Milwaukee County Grounds consists of large commercial users, so it is reasonable and logical to assume that their demand patterns are most similar to those of Milwaukee's commercial urban retail customer class.

As Shorewood has a mixed customer base, this analysis looked further into methods to determine its proposed peaking factors. The only available data for Shorewood demand patterns comes from their

monthly purchased water statistics found in their annual PSC reports. Comparing their total monthly water usage to Milwaukee's other wholesale customers, both in magnitude and fluctuation, does not yield any direct comparable customer that would clearly be reasonable to use for estimated peaking factors. However, Shorewood also does not appear to have extreme demand patterns in terms of either volume or variability. This leads to the conclusion that an average of the other wholesale customers' factors is appropriate. Table 19 shows two methods to determine peaking factors using averages of other wholesale customers' factors. The two methods are then averaged together to result in reasonable extra capacity peaking factors.

Table 19 - Shorewood Peak Ratio Analysis

	Brown Deer	Butler	Greendale	Menomonee Falls	Mequon	New Berlin	Wauwatosa	West Allis	Average
MD:AD Ratio	1.82	1.49	2.46	1.75	2.23	1.83	1.81	1.51	1.86
MD:MM Ratio (2012)	1.04	1.25	1.34	1.43	1.07	1.44	1.22	1.20	1.25
x MM:AD Ratio (2012)									1.44
MD:AD Ratio									1.79
Calculated Peaking Ratio									**1.83**
Extra Capacity Factor									**0.83**
2011 PSC Final Cost-of-Service Extra Capacity Factor									1.15
MH:AD Ratio	3.88	3.75	4.49	2.95	3.08	2.16	3.13	2.70	3.27
MH:MD Ratio	2.13	2.52	1.83	1.69	1.38	1.18	1.72	1.80	1.78
x MD:AD Ratio									1.83
MH:AD Ratio									3.26
Calculated Peaking Ratio									**3.26**
Extra Capacity Factor									**2.26**
2011 PSC Final Cost-of-Service Extra Capacity Factor									2.08

In the future, if more detailed and precise data becomes available for these two wholesale customers, an analysis could be performed to determine appropriate peaking factors with the same methodology used for the other wholesale customers.

SECTION VI: SYSTEM PUMPAGE ANALYSIS

For comparison, this study also analyzed total system pumpage on a daily and hourly basis, beginning with January 2012, to be consistent with the timeframe of the other sections of the study. Data through October 2013 was included in the analysis. Table 20 and Charts 27 and 28 summarize overall system pumpage during this time.

Table 20 - System Pumpage Summary

	System Total	Monthly Max Day	Monthly Max Hour	MD:AD Ratio for Prev. 12 Mos.	MH:AD Ratio for Prev. 12 Mos.
12-Jan	2,905,633,092	103,720,514	6,747,454		
12-Feb	2,769,308,886	101,117,053	4,681,212		
12-Mar	2,881,573,627	110,647,378	5,506,455		
12-Apr	2,796,888,806	100,811,583	4,895,793		
12-May	3,097,205,433	111,462,050	5,624,513		
12-Jun	3,733,264,960	143,981,128	6,893,687		
12-Jul	4,053,623,884	150,438,580	7,564,902		
12-Aug	3,652,200,824	138,303,508	6,922,654		
12-Sep	3,330,956,932	126,678,188	6,093,077		
12-Oct	3,151,173,847	112,813,279	5,628,503		
12-Nov	2,863,060,188	102,631,070	5,024,771		
12-Dec	2,914,506,980	98,634,273	4,599,710	1.44	1.74
13-Jan	3,080,873,287	106,566,837	5,640,769	1.44	1.73
13-Feb	2,882,337,563	109,317,197	5,737,001	1.43	1.72
13-Mar	3,084,775,840	104,244,623	6,664,782	1.42	1.71
13-Apr	2,891,490,380	101,168,815	4,709,902	1.42	1.71
13-May	3,083,158,031	108,303,559	4,918,269	1.42	1.71
13-Jun	3,100,552,143	115,010,629	5,984,285	1.44	1.74
13-Jul	3,469,072,465	139,438,554	6,669,500	1.36	1.62
13-Aug	3,498,776,945	130,942,590	8,836,633	1.36	2.07
13-Sep	3,170,829,341	123,562,324	5,449,269	1.37	2.08
13-Oct	3,097,645,060	154,731,982	7,643,162	1.52	2.08

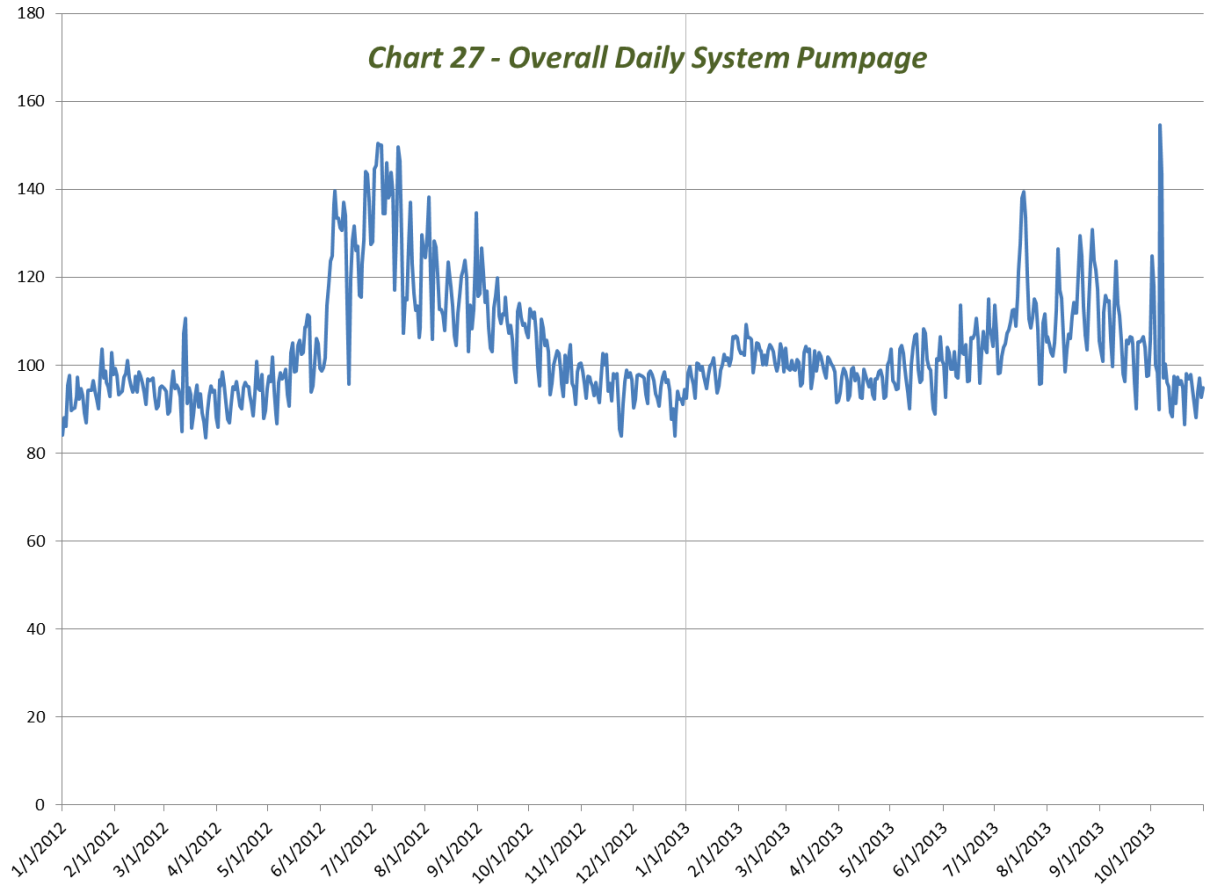


Chart 27 - Overall Daily System Pumpage
180
160
140
120
100
80
60
40
20
0
1/1/2012
2/1/2012
3/1/2012
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
11/1/2012
12/1/2012
1/1/2013
2/1/2013
3/1/2013
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013

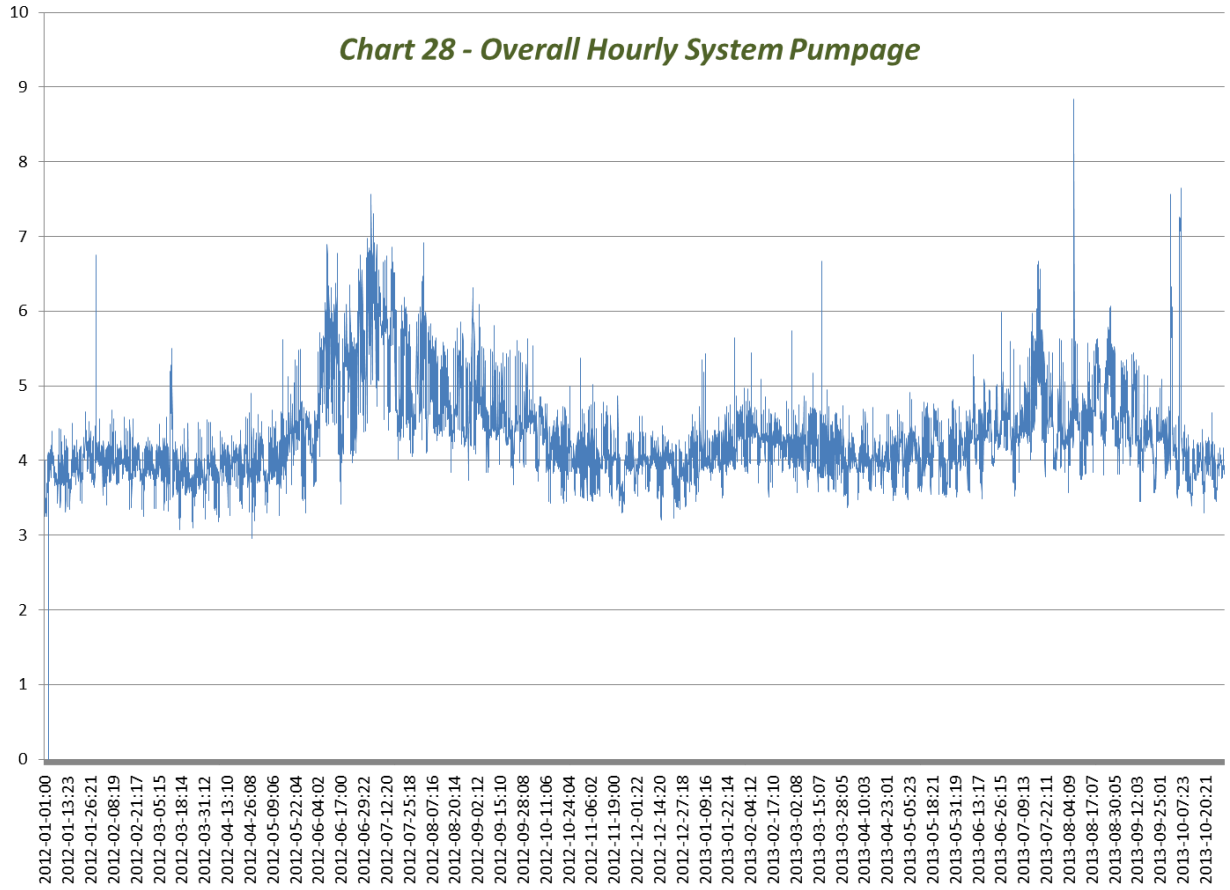


Chart 28 - Overall Hourly System Pumpage
10
9
8
7
6
5
4
3
2
1
0
2012-01-01:00
2012-01-13:23
2012-01-26:21
2012-02-08:19
2012-02-21:17
2012-03-05:15
2012-03-18:14
2012-03-31:12
2012-04-13:10
2012-04-26:08
2012-05-09:06
2012-05-22:04
2012-06-04:02
2012-06-17:00
2012-06-29:22
2012-07-12:20
2012-07-25:18
2012-08-07:16
2012-08-20:14
2012-09-02:12
2012-09-15:10
2012-09-28:08
2012-10-11:06
2012-10-24:04
2012-11-06:02
2012-11-19:00
2012-12-01:22
2012-12-14:20
2012-12-27:18
2013-01-09:16
2013-01-22:14
2013-02-04:12
2013-02-17:10
2013-03-02:08
2013-03-15:07
2013-03-28:05
2013-04-10:03
2013-04-23:01
2013-05-05:23
2013-05-18:21
2013-05-31:19
2013-06-13:17
2013-06-26:15
2013-07-09:13
2013-07-22:11
2013-08-04:09
2013-08-17:07
2013-08-30:05
2013-09-12:03
2013-09-25:01
2013-10-07:23
2013-10-20:21

SECTION VII: RETAIL SAMPLE ANALYSIS

ANALYSIS OF SAMPLE DATA

This section summarizes the retail customer data collected during the sample periods and determines the conclusions that can be reached from the sample data. The data were also interpreted to determine reasonable peaking factors to be used in the next PSC water rate case. This study used meters installed in 2012 and 2013. Water Works staff collected data from 398 meters in total: 206 for residential customers, 124 for commercial customers, 40 for industrial customers and 28 for public authority customers.

Data Limitations

The goal of the analysis was to collect a sample during the time that the peak for each customer class would be expected to occur, determine the peak of the sample, compare the peak usage to average usage based on billing records for the sample customers and calculate the appropriate peaking factors (max day, max hour) for each customer class. Due to unexpected circumstances, the sample data limited the ability to determine peaking factors according to the intended methodology. Several types of gaps in the data were identified:

1. Sampling period dates – Because of difficulties receiving the meters from suppliers and receiving specific instructions on how to collect data from the meters, the timeframe for two of the three sample periods was not the season when the peak day and hour were expected to occur. This is especially true for the residential and commercial customer classes. In 2012, the earliest reading date for any residential meter is August 4, 2012 and the latest is November 13, 2012. In all likelihood, the peak for the residential class occurred earlier in the summer months. Similarly, commercial reading dates are between June 29 and November 13; industrial reading dates are between August 13 and November 12; and public authority reading dates are also between August 13 and November 12. Based on the historical customer analysis, the commercial class peak would be expected to occur during mid-summer, the industrial class during late summer and the public authority class during late summer to early autumn. In 2013, the first sample reading dates were from April 7 and May 13 and the second sample period was from July 14 through August 8.
2. Staggered data points – Because of limitations on the amount of data that each meter can store before it can be downloaded and reset (each meter could only store 40 days' worth of data), the sample data is staggered so that on any particular day, some meters might be not have recorded that day's usage. This is important because peaking factors are determined based on the collective peak usage of the entire customer class, not a summation of the peak usage of individual meters. This is an important distinction. Because the data does not have a consistent number of meters (and the same meters) for each day, it causes difficulty for the analysis to determine the collective peak for each customer class. In this sample, there are periods of time that have data for a consistent number of meters, but not all of them and not for the entire sampling duration.
3. Unit precision – The sample meters recorded in units ranging from tenths of cubic feet to thousand cubic feet, depending on the size of the meter. The data were adjusted in order to

make the units consistent within each class; however, they are not consistent between classes – residential and commercial readings were analyzed in tenths of cubic feet and industrial and public authority readings were analyzed in cubic feet. The impact of the adjustments was a slight loss in precision for some of the largest meters, although this impact is negligible.

4. Sample size – The methodology attempted to determine both an appropriate and a reasonable sample size that would accurately reflect the usage characteristics of the entire customer class. The actual sample size collected, because of a shortage in equipment, is smaller than originally anticipated.

Even with these data limitations, the analysis was performed and many theories and conclusions can be drawn from the data. Due to the data, the analysis was performed in a manner different from what was envisioned when designing the methodology for this study. However, the results of the analysis can be applied to available data in order to calculate reasonable peaking factors for retail customer classes.

Summary and Analysis of Statistical Data

For each sample meter, the data included the date of the water usage and the amount of usage during each hour for that date. From the information, the analysis could determine the total daily water consumption, the maximum daily water consumption for the sample period, the average daily water consumption, the maximum hourly consumption for each day and the maximum hourly consumption for the sample period for each sample meter. In order to determine statistics for each customer class as a whole, the individual meter data, sorted by customer class, was summed on both a daily and hourly basis. Summary statistics during each sample period for each customer class are shown in Tables 21, 22 and 23.

Due to the limitations of the dataset, as was discussed, the focus of the analysis was on relationships among various statistics within each customer class and between each customer class, rather than calculating a precise peaking factor for the class during the last year. However, statistics were also calculated in a manner that would have been performed as the methodology was originally designed. All assumptions used are explained in the following sections.

Table 21 - Summary Usage and Peaking Statistics by Customer Class - October/November 2012

	Residential Sample	Commercial Sample	Industrial Sample	Public Authority Sample	Commercial Meters Multi-Family Sample	Commercial Meters Non-Multi-Family Sample
Selected Dataset Statistics (within sample period)						
Sample Dates	10/10-11/5	10/5-11/5	10/11-11/7	10/4-11/5	10/5-11/5	10/5-11/5
Number of Meters	99	71	11	18	21	50
Average of individual Max Day:Avg Day ratios	2.609	2.481	6.502	2.304	1.598	2.852
Median of individual Max Day:Avg Day ratios	2.056	1.873	1.281	1.684	1.390	2.004
Maximum of individual Max Day:Avg Day ratios	16.179	17.778	28.000	7.106	3.549	17.778
Minimum of individual Max Day:Avg Day ratios	1.287	1.014	1.007	1.157	1.014	1.119
Combined Average Day usage	20,917	122,721	35,716	18,997	82,096	40,625
Sum of individual Max Day usage (non-coincident max day)	48,417	201,802	46,522	41,925	111,389	90,413
Customer class non-coincident Max Day:Avg Day ratio	2.315	1.644	1.303	2.207	1.357	2.226
Maximum combined daily usage	24,919	142,394	41,120	30,657	100,957	59,465
Customer class coincident Max Day:Avg Day ratio	1.191	1.160	1.151	1.614	1.230	1.464
Average of individual Max Hour:Avg Day ratios	17.858	17.115	105.139	11.899	5.380	22.043
Median of individual Max Hour:Avg Day ratios	13.249	7.620	3.096	3.823	5.117	9.971
Maximum of individual Max Hour:Avg Day ratios	74.037	341.333	588.000	63.080	13.061	341.333
Minimum of individual Max Hour:Avg Day ratios	5.172	1.365	1.019	1.441	1.365	2.563
Combined Average Day usage	20,917	122,721	35,716	18,997	82,096	40,625
Sum of individual Max Hour usage (non-coincident max hour)	295,056	705,360	117,749	199,169	264,960	440,400
Customer class non-coincident Max Hour:Avg Day ratio	14.106	5.748	3.297	10.484	3.227	10.841
Maximum combined hourly usage	45,336	311,712	69,535	86,309	154,200	221,760
Customer class coincident Max Hour:Avg Day ratio	2.167	2.540	1.947	4.543	1.878	5.459

Table 22 - Summary Usage and Peaking Statistics by Customer Class - April/May 2013

	Residential Sample	Commercial Sample	Industrial Sample	Public Authority Sample	Commercial Meters Multi-Family Sample	Commercial Meters Non-Multi-Family Sample
Selected Dataset Statistics (within sample period)						
Sample Dates	4/7 - 5/13	4/7 - 5/13	4/6 - 5/13	4/6 - 5/13	4/7 - 5/13	4/7 - 5/13
Number of Meters	101	72	12	8	24	48
Average of individual Max Day:Avg Day ratios	2.653	3.043	5.023	2.376	1.914	3.620
Median of individual Max Day:Avg Day ratios	2.272	1.915	2.348	1.931		
Maximum of individual Max Day:Avg Day ratios	19.271	18.500	20.900	5.743		
Minimum of individual Max Day:Avg Day ratios	1.183	1.134	1.174	1.192		
Combined Average Day usage	24,902	86,299	35,116	16,344	42,578	43,721
Sum of individual Max Day usage (non-coincident max day)	53,901	184,419	62,638	37,882	70,316	114,103
Customer class non-coincident Max Day:Avg Day ratio	2.165	2.137	1.784	2.318	1.651	2.610
Maximum combined daily usage	29,349	124,956	53,853	24,690	49,484	75,472
Customer class coincident Max Day:Avg Day ratio	1.179	1.448	1.534	1.511	1.162	1.726
Average of individual Max Hour:Avg Day ratios	20.690	27.244	69.573	6.552	7.848	37.148
Median of individual Max Hour:Avg Day ratios	13.263	8.611	2.727	4.031		
Maximum of individual Max Hour:Avg Day ratios	166.500	444.000	501.600	23.350		
Minimum of individual Max Hour:Avg Day ratios	2.572	2.670	1.256	1.573		
Combined Average Day usage	24,902	86,299	35,116	16,344	42,578	43,721
Sum of individual Max Hour usage (non-coincident max hour)	318,696	787,488	87,180	133,968	209,328	578,160
Customer class non-coincident Max Hour:Avg Day ratio	12.798	9.125	2.483	8.197	4.916	13.224
Maximum combined hourly usage	54,816	247,176	63,466	88,512	78,240	183,000
Customer class coincident Max Hour:Avg Day ratio	2.201	2.864	1.807	5.416	1.838	4.186

Table 23 - Summary Usage and Peaking Statistics by Customer Class - July/August 2013

	Residential Sample	Commercial Sample	Industrial Sample	Public Authority Sample	Commercial Meters Multi-Family Sample	Commercial Meters Non-Multi-Family Sample
Selected Dataset Statistics (within sample period)						
Sample Dates	7/14 - 8/8	7/14 - 8/8	7/13 - 8/12	7/14 - 8/8	7/14 - 8/8	7/14 - 8/8
Number of Meters	185	90	35	26	24	66
Average of individual Max Day:Avg Day ratios	2.845	3.192	1.871	1.844	2.697	3.377
Median of individual Max Day:Avg Day ratios	2.198	1.970	1.699	1.586		
Maximum of individual Max Day:Avg Day ratios	13.813	22.735	5.180	3.914		
Minimum of individual Max Day:Avg Day ratios	1.125	1.051	1.088	1.027		
Combined Average Day usage	53,738	138,471	441,447	182,399	78,336	60,136
Sum of individual Max Day usage (non-coincident max day)	154,844	292,399	632,182	249,574	143,057	149,342
Customer class non-coincident Max Day:Avg Day ratio	2.881	2.112	1.432	1.368	1.826	2.483
Maximum combined daily usage	75,384	185,770	557,144	221,121	103,648	94,032
Customer class coincident Max Day:Avg Day ratio	1.403	1.342	1.262	1.212	1.323	1.564
Average of individual Max Hour:Avg Day ratios	20.289	17.580	5.801	5.579	7.717	21.279
Median of individual Max Hour:Avg Day ratios	15.418	10.671	3.650	2.743		
Maximum of individual Max Hour:Avg Day ratios	92.726	179.703	21.462	60.387		
Minimum of individual Max Hour:Avg Day ratios	3.000	1.106	1.167	1.190		
Combined Average Day usage	53,738	138,471	441,447	182,399	78,336	60,136
Sum of individual Max Hour usage (non-coincident max hour)	929,304	857,064	1,125,216	457,368	310,464	546,600
Customer class non-coincident Max Hour:Avg Day ratio	17.293	6.189	2.549	2.508	3.963	9.089
Maximum combined hourly usage	140,520	316,176	761,424	318,456	161,496	194,640
Customer class coincident Max Hour:Avg Day ratio	2.615	2.283	1.725	1.746	2.062	3.237

Residential Analysis

For each customer, statistics were tabulated for the average day usage, maximum day usage and maximum hour usage during each sample period, from available data. As shown on Tables 21 through 23, for the residential class, the first sample period ran from October 10 to November 5, 2012 and included 99 residential customers. The second sample period ran from April 7 to May 13, 2013 and included 101 residential customers. The third sample period was between July 14 and August 8, 2013 and contained 185 residential customers.

The combined average day usage during the first sample period is 20,917 units. When examining the coincident peak (summing usage on each day for all customers, then taking the peak of the daily totals), the analysis shows maximum daily usage of 24,919 units for the first sample period. This results in a residential sample MD:AD ratio of 1.191. The sum of all of the individual customers' non-coincident maximum daily usages totals 48,417 units, yielding a non-coincident MD:AD ratio of 2.315. The difference between the non-coincident MD:AD ratio (2.315) and the coincident MD:AD ratio (1.191) illustrates why statistics for individual meters cannot be used by themselves to determine peaking factors for an entire class. To illustrate this further, the smallest MD:AD ratio for any one residential customer (1.287) is greater than the MD:AD ratio for the entire sample (1.191).

The same statistics are also presented for hourly water usage. Just as with the daily data, the non-coincident MH:AD ratio and coincident MH:AD ratio were calculated and compared to each other. The sum of all customers' maximum hourly usage (the greatest amount of usage in any one hour throughout the sample period for each customer) was 295,056 units, resulting in a non-coincident MH:AD ratio of 14.106. The composite sample maximum hourly usage was calculated to 45,336 units, resulting in a coincident MH:AD ratio of 2.167. This further demonstrates the "muting" effect of a large number of customers – how the statistics of the individual meters do not relate to the statistics of the class as a whole. Again, the smallest MH:AD for any one customer (5.172) is significantly greater than the calculated coincident MH:AD ratio for the total sample (2.167).

The same analysis is shown for the second sample period in Table 22. For the residential sample, average daily usage during this time was 24,902 units. The peak daily usage during the same period was 29,349 units, for a MD:AD ratio of 1.179. This is virtually the same as the ratio in the first sample period. The hourly data shows a similar result. The maximum coincident hourly usage was 54,816 during this period. This calculates to a MH:AD ratio of 2.201 for this sample period; again, this is similar to the first period.

The same analysis is shown for the third sample period in Table 23. For the residential sample, average daily usage during this time was 53,738 units. The peak daily usage during the same period was 75,384 units, for a MD:AD ratio of 1.403. This is significantly higher than in the first period, as well as the sample period from the prior study. However, it cannot be known at this time if the cause of the higher ratio is because of the time period was the peak month during 2013 or if it is more due to random variation. The hourly data shows a similar result. The maximum coincident hourly usage was 140,520 during this period. This calculates to a MH:AD ratio of 2.615 for this sample period; again, this is higher than previous periods. The following charts (Charts 29 -34) show residential sample meter usage demand patterns for each sample period.

Chart 29 - Daily Residential Water Usage by Customer and Total Sample (10/10 - 11/5)

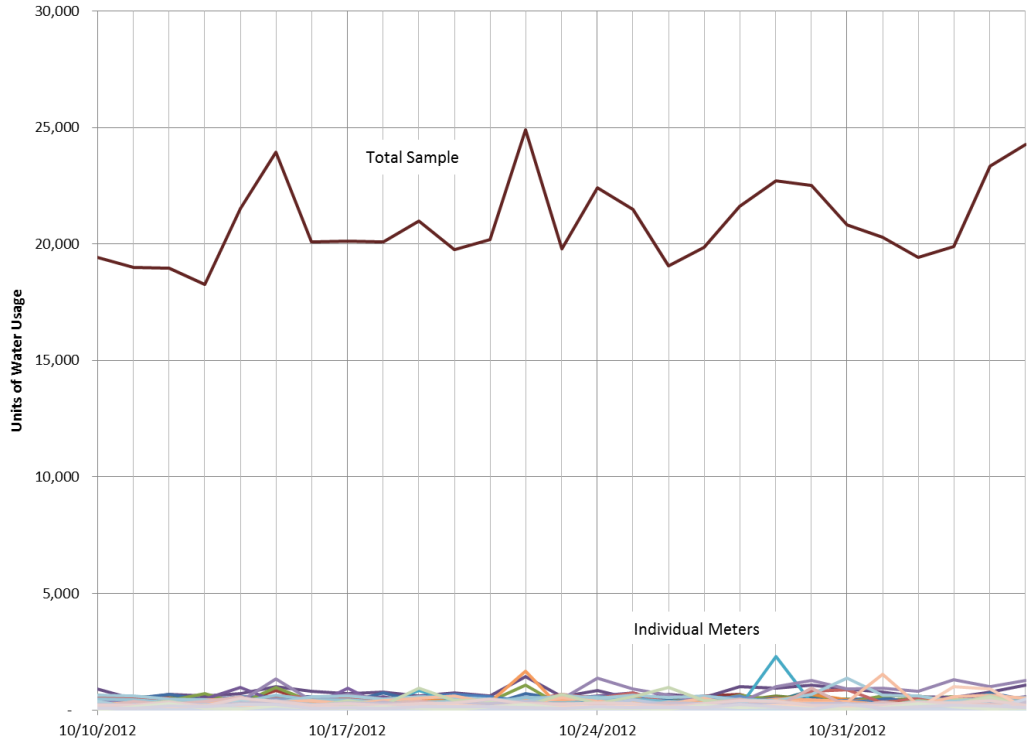


Chart 30 - Hourly Residential Sample Usage by Day (10/10 - 11/5)

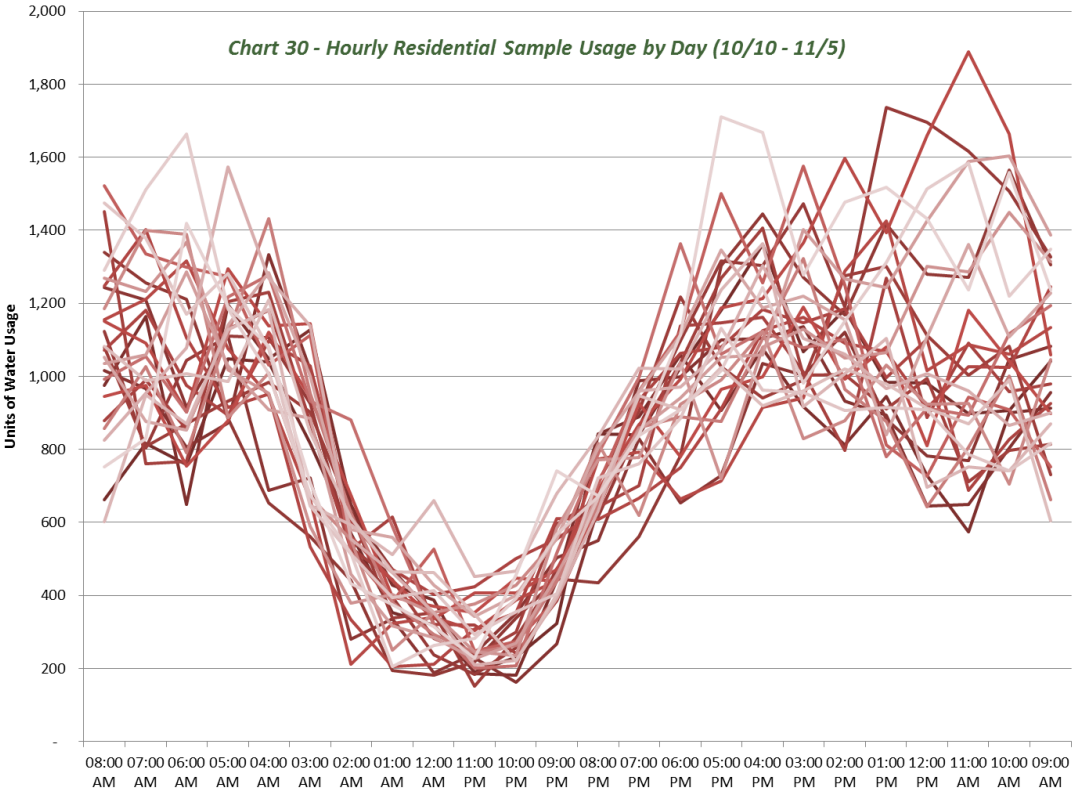


Chart 31 - Daily Residential Water Usage by Customer and Total Sample (4/7 - 5/13)

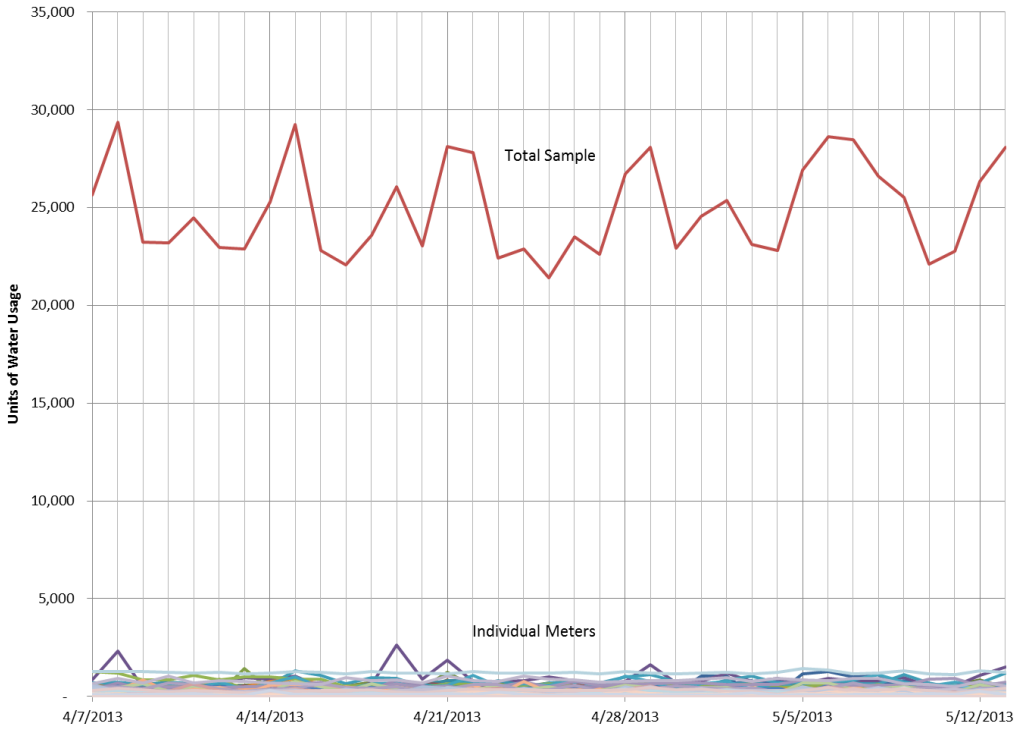


Chart 32 - Hourly Residential Sample Usage by Day (4/7 - 5/13)

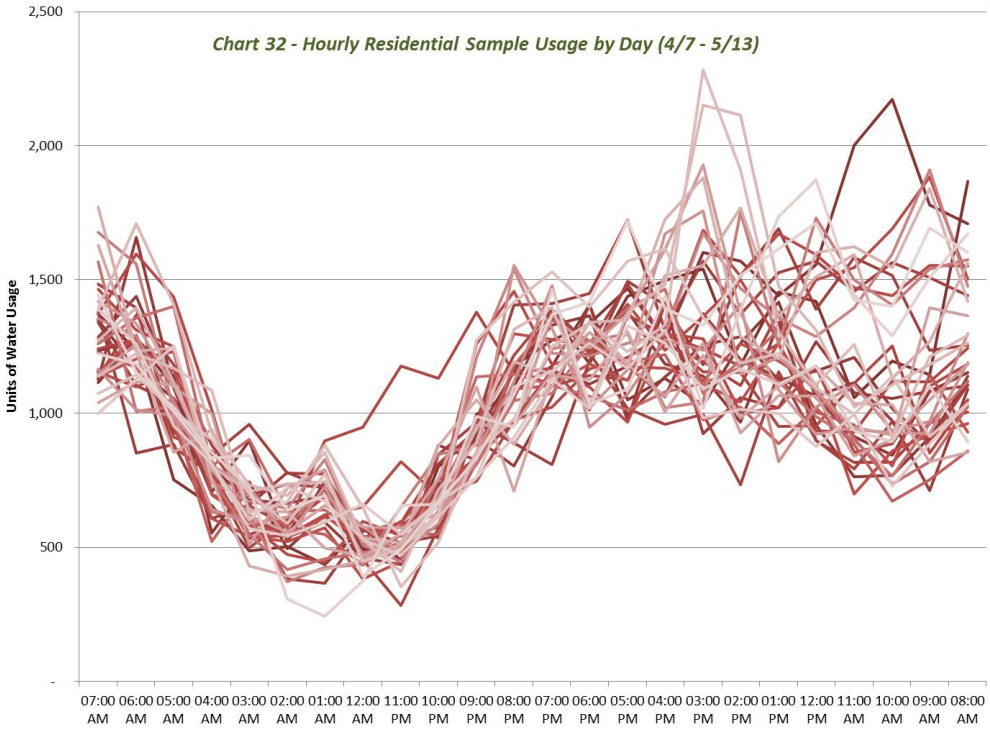


Chart 33 - Daily Residential Water Usage by Customer and Total Sample (7/14 - 8/8)

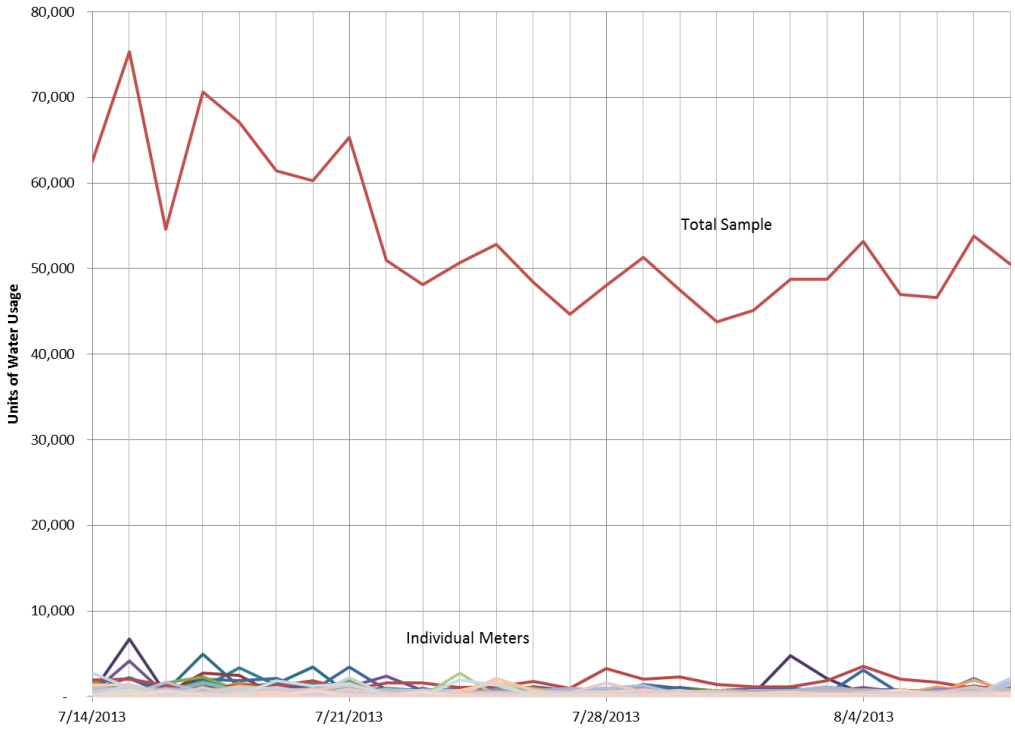
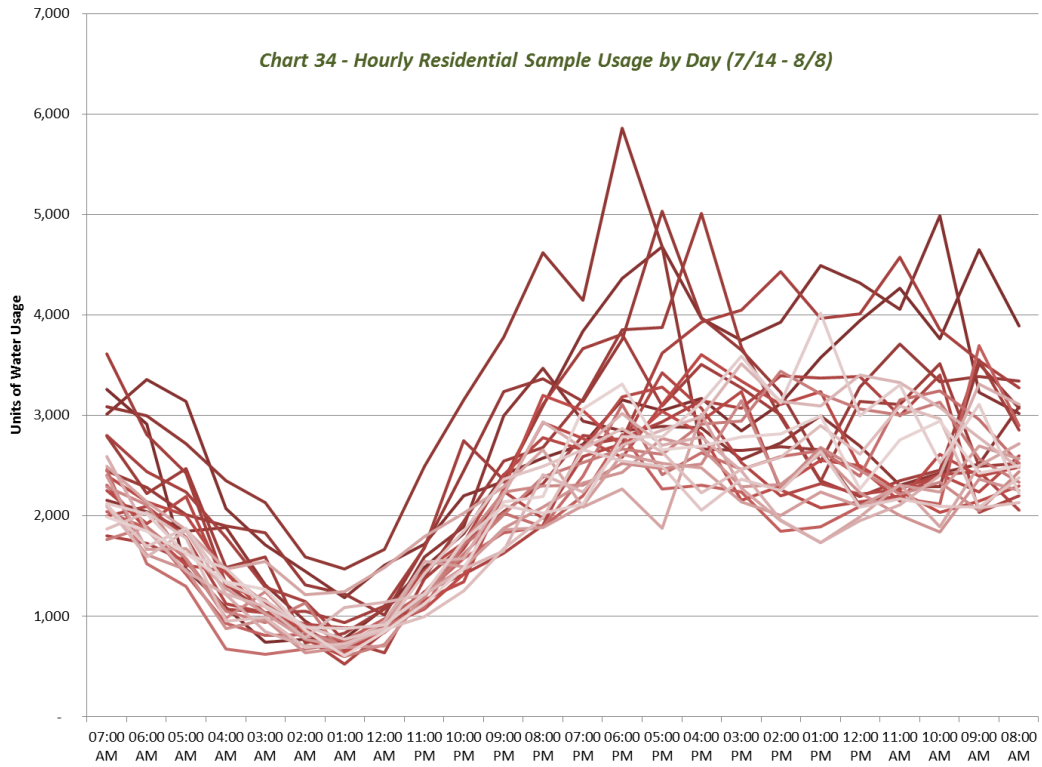


Chart 34 - Hourly Residential Sample Usage by Day (7/14 - 8/8)



Commercial Analysis

The same statistical analysis was performed for the commercial meters; data was collected for 71 commercial customer meters during the first sample period, 72 during the second sample period and 90 during the third sample period. The differences between statistics for individual customers versus those of the commercial sample as a whole are similar to those in the residential sample. During the first sample period, spanning October 5 through November 5, 2012, the combined average usage was 122,721 units. Combined peak usage for the sample as a whole during this time was 142,394 units, resulting in a coincident MD:AD ratio of 1.160. This result is slightly lower than the ratio during the same period for the residential sample meters. For hourly usage, the peak usage in any hour during the sample period was 311,712 units, which resulted in a coincident MH:AD ratio of 2.540. This was significantly more than the ratio for residential meters.

The second sample period showed somewhat different results from the first period. Average combined daily usage during the period from April 7 to May 13 was 86,299 units. The peak combined daily usage for the sample was 124,956 units, resulting in a coincident MD:AD ratio of 1.448, significantly higher than that for the first period. The peak hourly usage during this period was 247,176 units, resulting in a coincident MH:AD ratio of 2.864; again, higher than the first period's result.

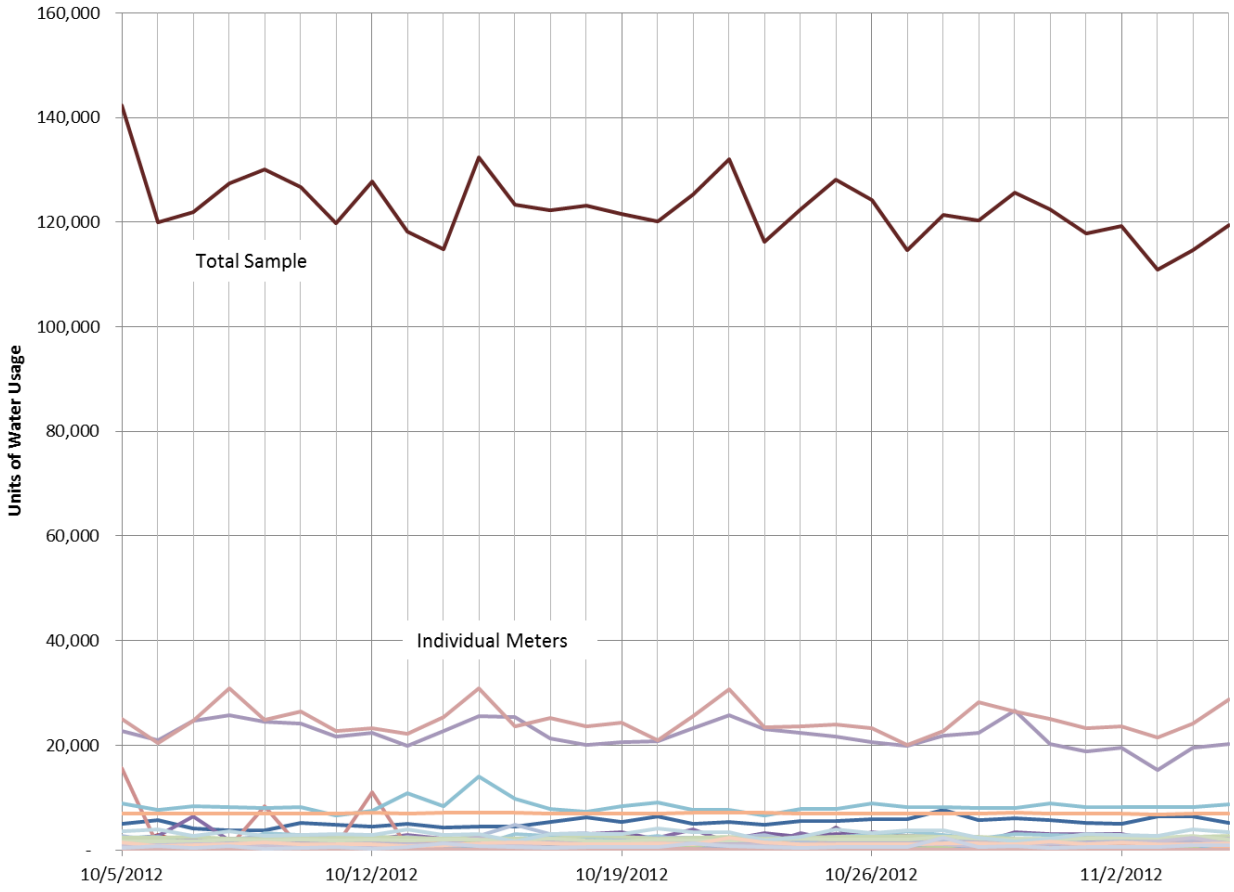
The third sample period showed somewhat different results for the commercial customers, with a slightly different mix of meters. Average combined daily usage during the period from July 14 to August 8 was 138,471 units. The peak combined daily usage for the sample was 185,770 units, for a coincident MD:AD ratio of 1.342, in between the other two sample periods. Peak hourly usage was 316,176 units, resulting in a coincident MH:AD ratio of 2.283; this is actually less than the ratio during the other periods.

Further analysis was performed on the commercial sample data by isolating meters installed on multi-family customers from those of other commercial customers and performing the same statistical analyses. The PSC has recently instituted rules that utilities must begin to report multi-family users as a separate customer class, and these two subgroups of customers could exhibit different characteristics that would have an effect on the demand characteristics of the total commercial customer class. In the first sample period, there were 21 meters installed on multi-family customers and 50 on non-multi-family commercial customers. Within the second sample period, there were 24 meters installed on multi-family customers and 48 meters on non-multi-family commercial customers. During the third period, there were 24 multi-family meters measured and 66 non-multi-family meters measured. Without highlighting the specific figures, this section will discuss general results and conclusions.

The most striking aspect of the statistics when isolating the two subgroups is how the coincident peaking factors for both subgroups differ significantly from those of the total commercial sample. This occurs for both MD:AD and MH:AD ratios. The multi-family group is generally lower than the total commercial sample, while the other commercial customers generally have higher ratios than the total commercial sample. This illustrates the "muting" effect of combining two subclasses of customers that have different usage characteristics. Their different peaking characteristics tend to cancel each other out to create lower peaking factors for the larger combined customer class. Another notable feature is that for all coincident peaking factors, the multi-family subgroup has lower peaking factors than the remaining subgroup of commercial customers. These effects can be seen in Charts 41 through 46. This reconciles with the historical analysis that showed that even though the largest commercial customers

tended to have higher seasonal peaks than smaller customers, the commercial class as a whole showed seasonal peaks lower than those of the largest customers.

Chart 35 - Daily Commercial Water Usage by Customer and Total Sample (10/5 - 11/5)



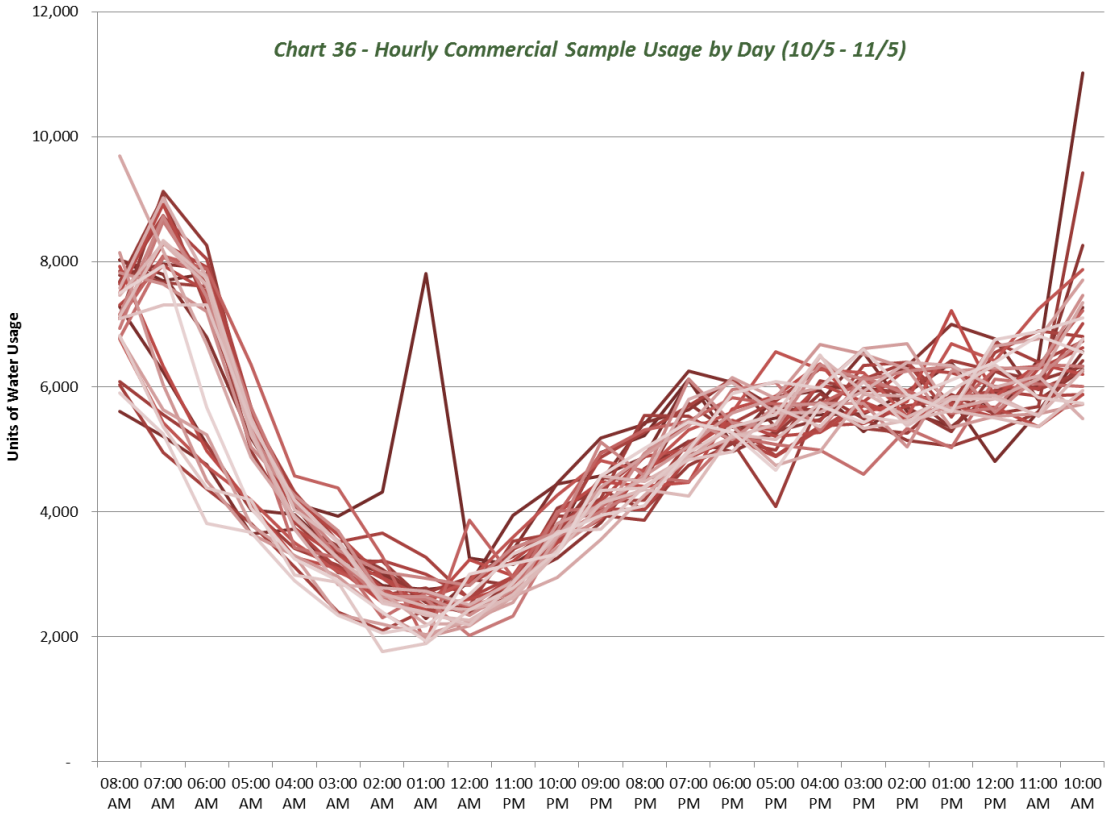


Chart 36 - Hourly Commercial Sample Usage by Day (10/5 - 11/5)
Units of Water Usage
12,000
10,000
8,000
6,000
4,000
2,000
-
08:00 AM
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM

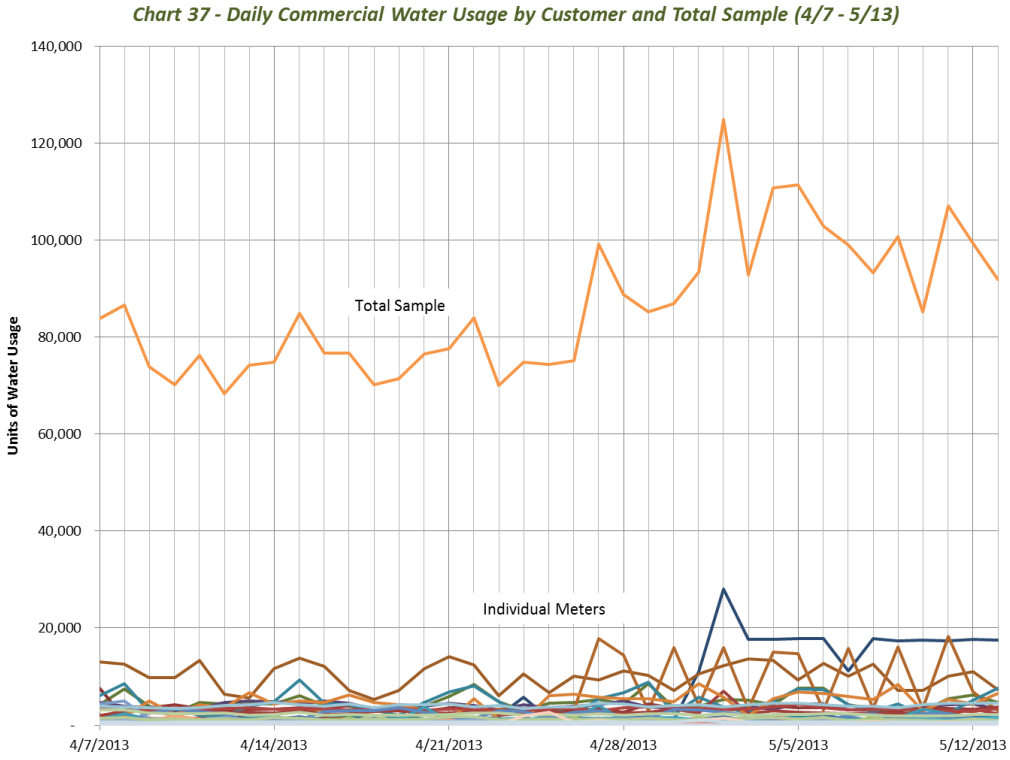


Chart 37 - Daily Commercial Water Usage by Customer and Total Sample (4/7 - 5/13)
Units of Water Usage
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Total Sample
Individual Meters
4/7/2013
4/14/2013
4/21/2013
4/28/2013
5/5/2013
5/12/2013

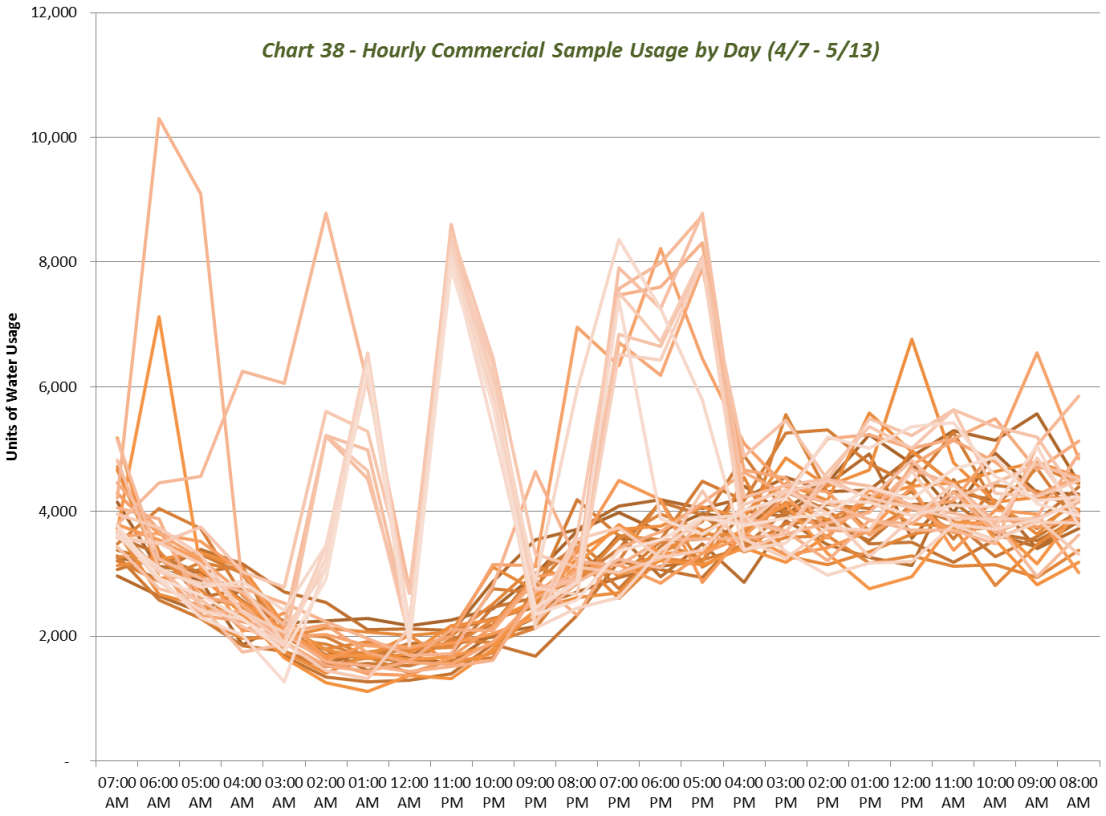


Chart 38 - Hourly Commercial Sample Usage by Day (4/7 - 5/13)
Units of Water Usage
12,000
10,000
8,000
6,000
4,000
2,000
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

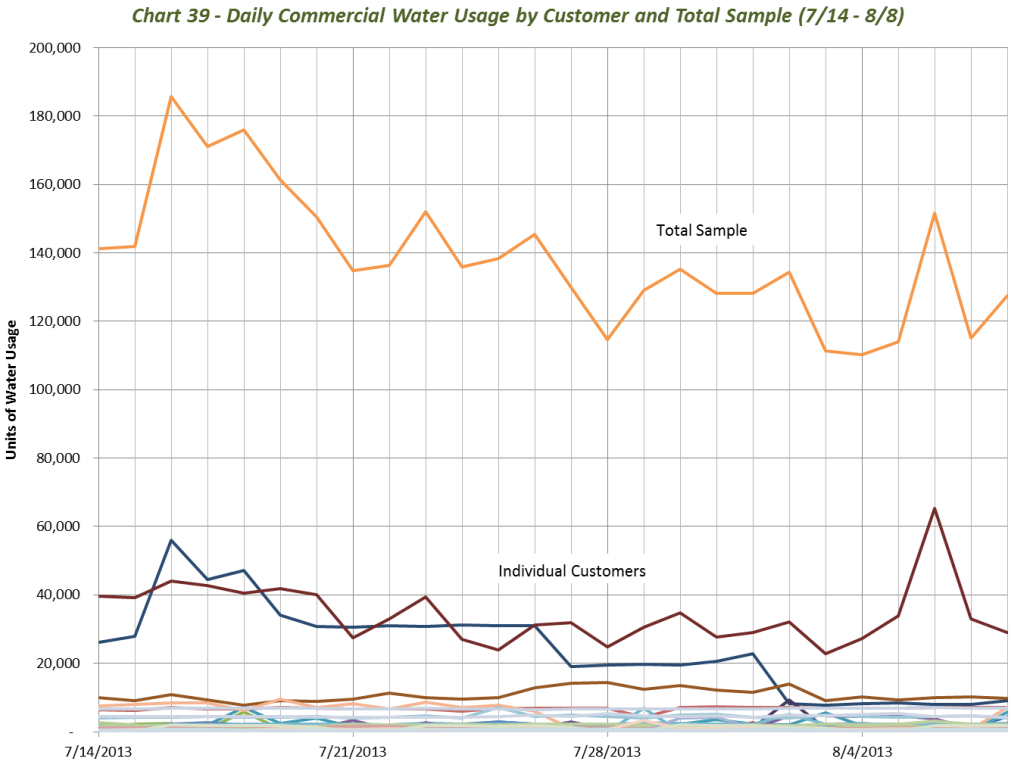


Chart 39 - Daily Commercial Water Usage by Customer and Total Sample (7/14 - 8/8)
Units of Water Usage
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Total Sample
Individual Customers
7/14/2013
7/21/2013
7/28/2013
8/4/2013

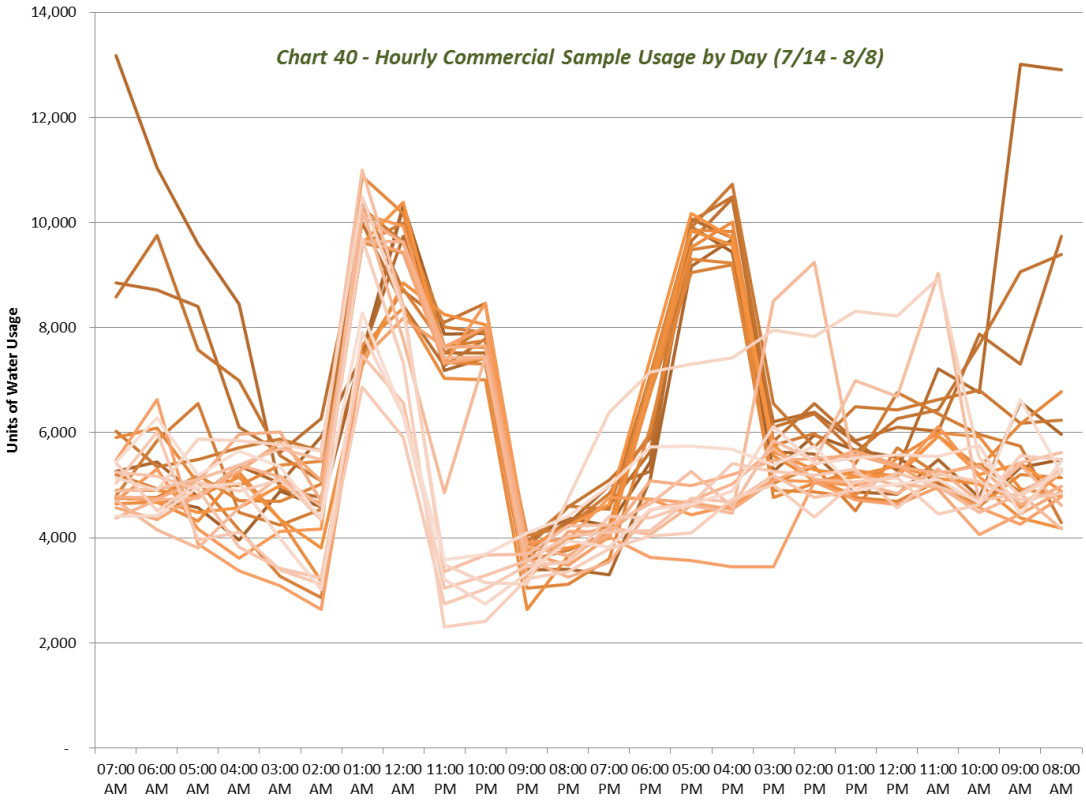


Chart 40 - Hourly Commercial Sample Usage by Day (7/14 - 8/8)
Units of Water Usage
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

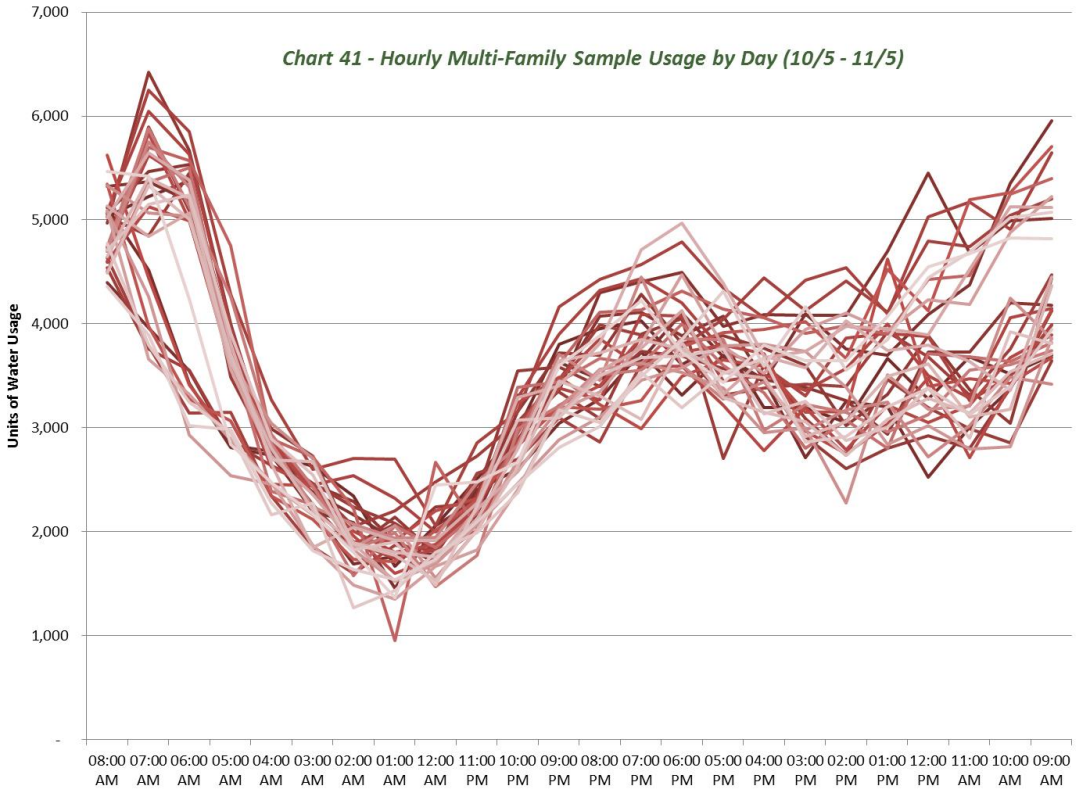


Chart 41 - Hourly Multi-Family Sample Usage by Day (10/5 - 11/5)
Units of Water Usage
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
08:00 AM
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM

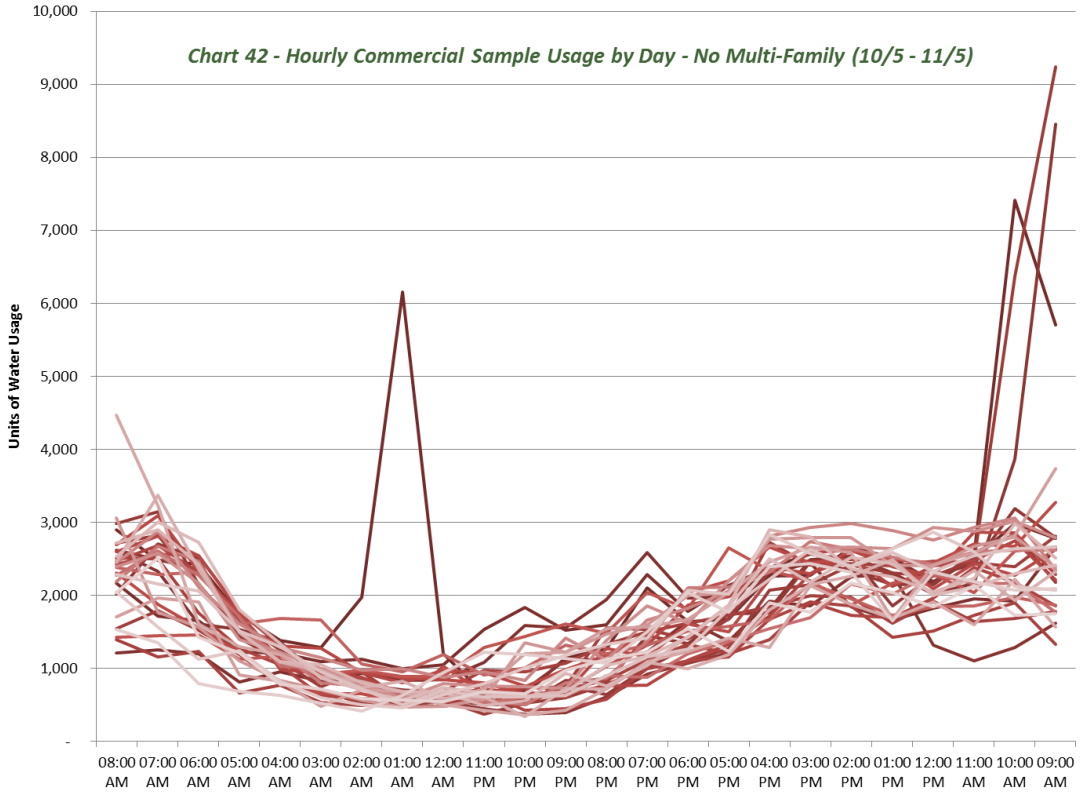


Chart 42 - Hourly Commercial Sample Usage by Day - No Multi-Family (10/5 - 11/5)
Units of Water Usage
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
08:00 AM
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM

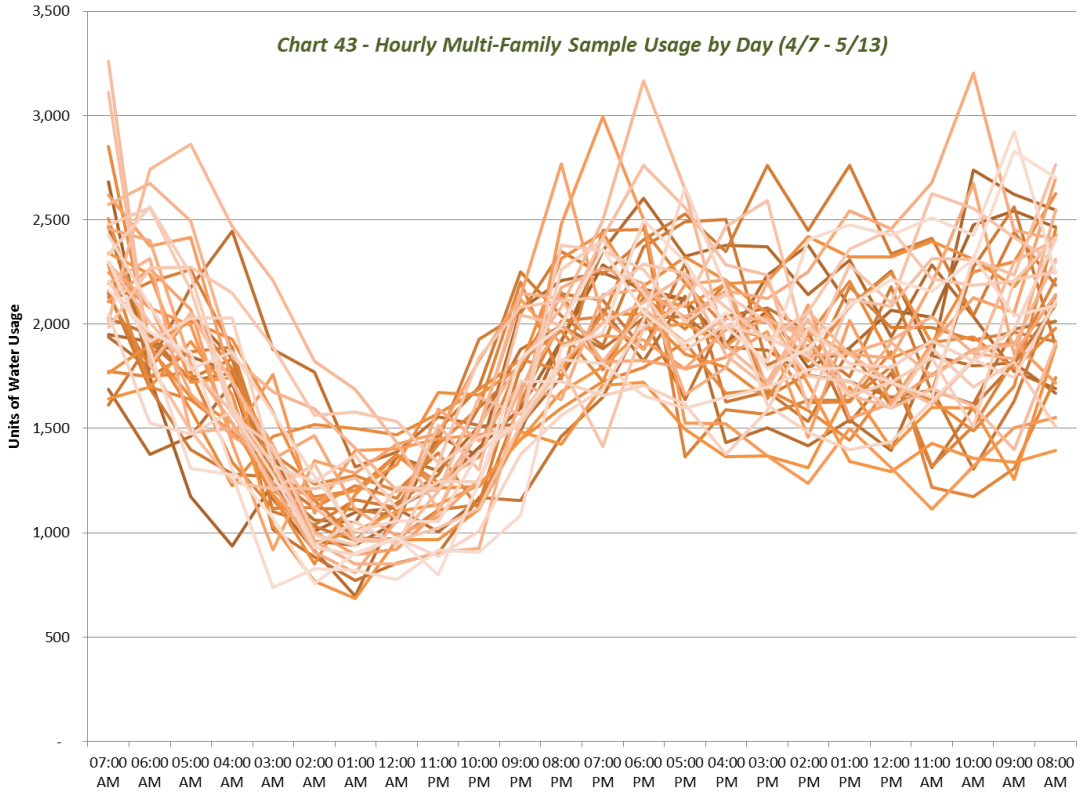


Chart 43 - Hourly Multi-Family Sample Usage by Day (4/7 - 5/13)
Units of Water Usage
3,500
3,000
2,500
2,000
1,500
1,000
500
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

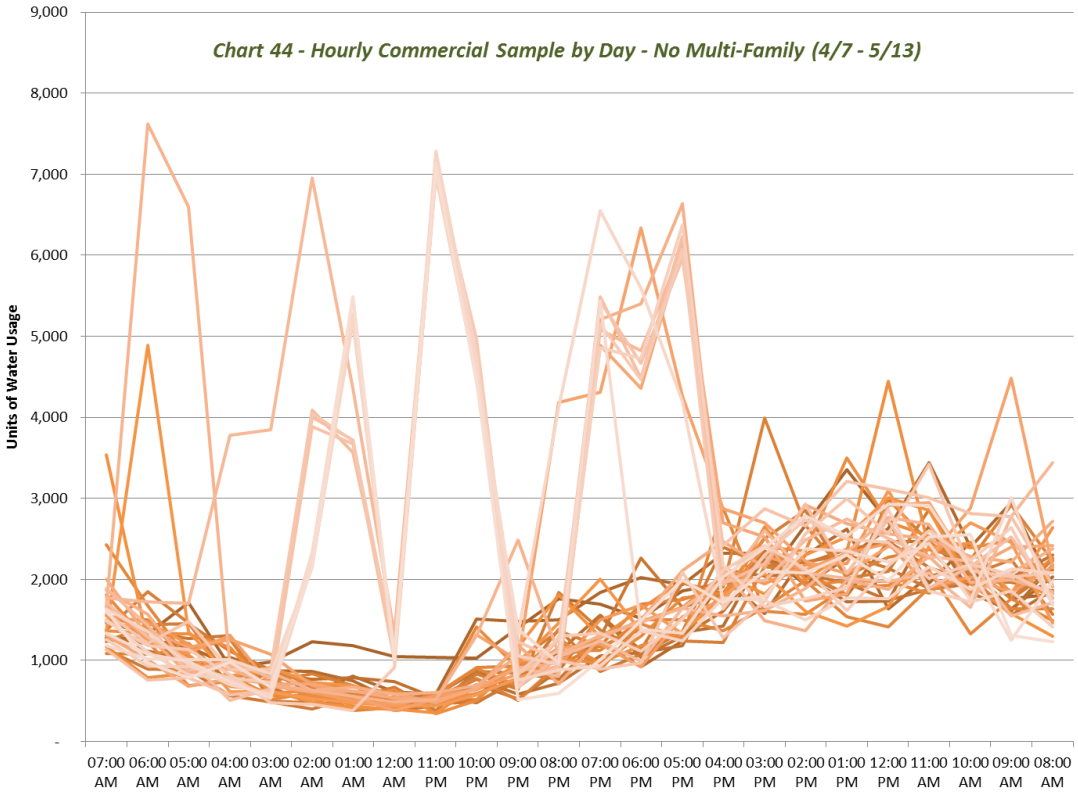


Chart 44 - Hourly Commercial Sample by Day - No Multi-Family (4/7 - 5/13)
Units of Water Usage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

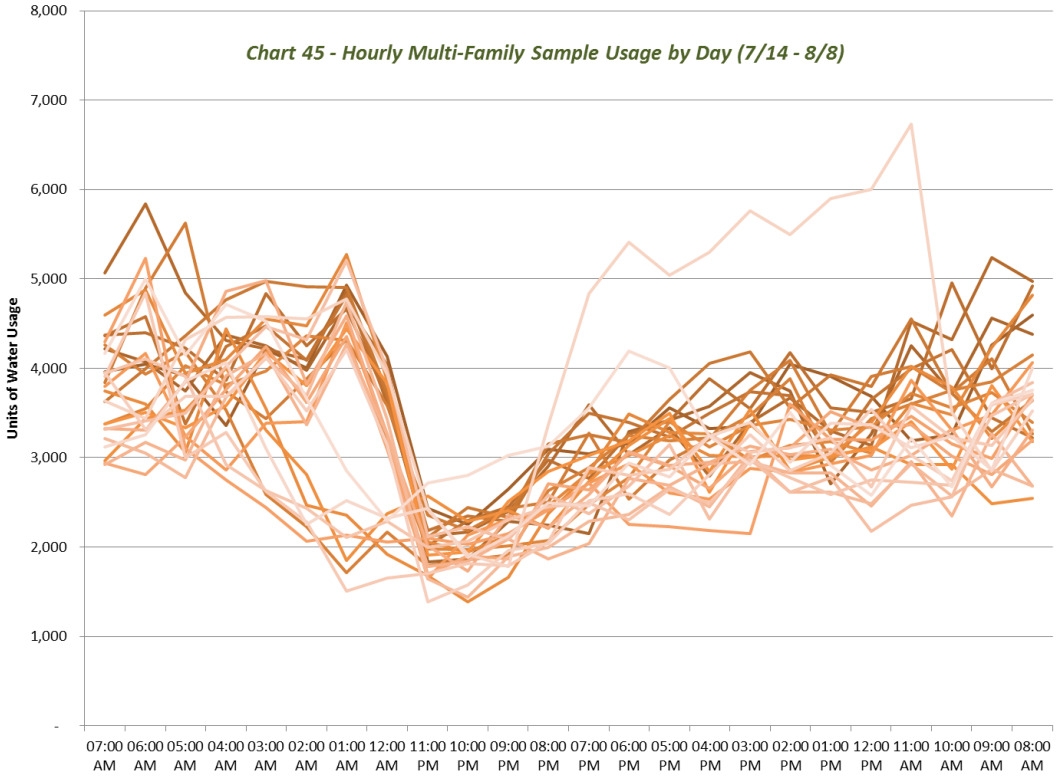


Chart 45 - Hourly Multi-Family Sample Usage by Day (7/14 - 8/8)
Units of Water Usage
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

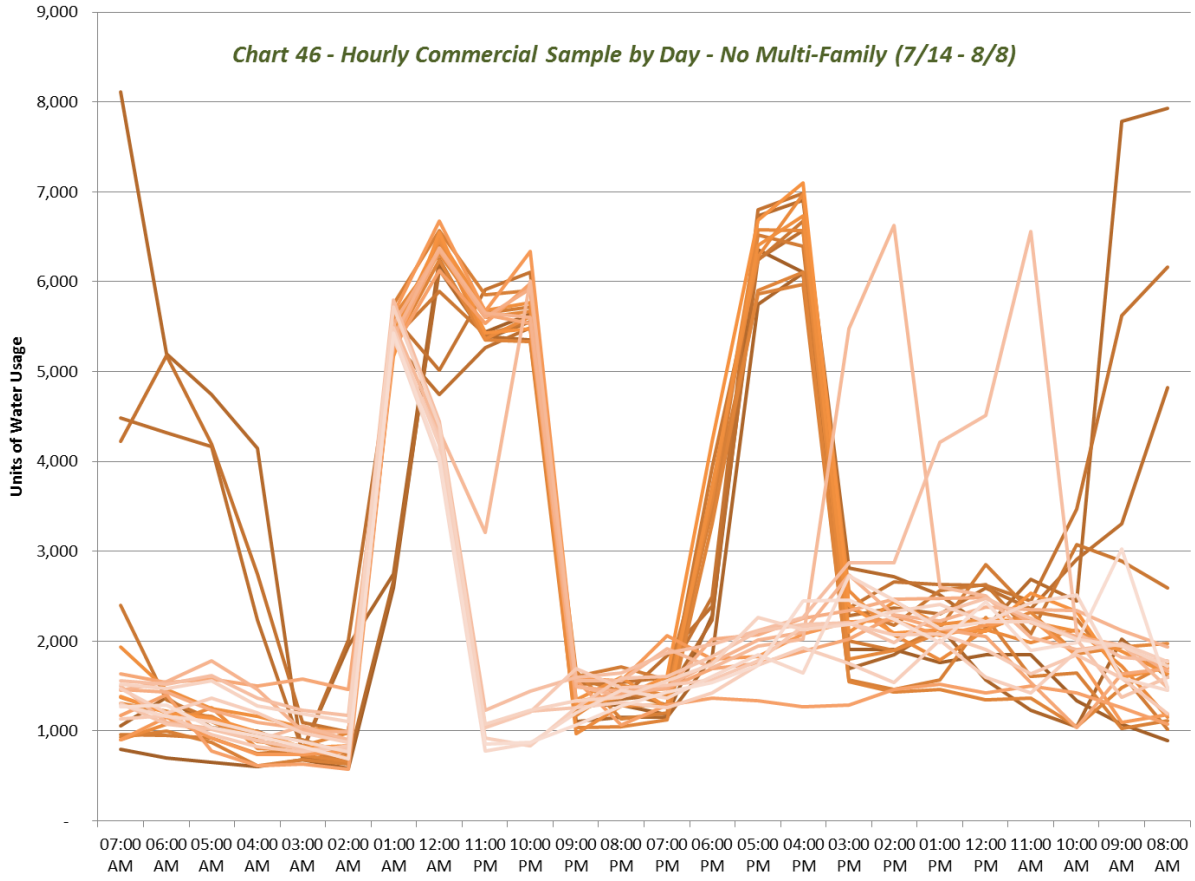


Chart 46 - Hourly Commercial Sample by Day - No Multi-Family (7/14 - 8/8)
Units of Water Usage
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
07:00 AM
06:00 AM
05:00 AM
04:00 AM
03:00 AM
02:00 AM
01:00 AM
12:00 AM
11:00 PM
10:00 PM
09:00 PM
08:00 PM
07:00 PM
06:00 PM
05:00 PM
04:00 PM
03:00 PM
02:00 PM
01:00 PM
12:00 PM
11:00 AM
10:00 AM
09:00 AM
08:00 AM

Industrial Analysis

Eleven meters were initially installed in 2012 for the sample of industrial customers. During the sampling process, it was determined based on the analysis of historical data that a relatively small number of customers make up most of the industrial class's water consumption and, therefore, its peaking characteristics as well. The statistical analysis of the 11 industrial customers for the first sample period from 2012 is shown in Table 21. As with the commercial sample, the summary shows a large variation in MD:AD ratios of the individual customers. The ratios range from a low of 1.007 to a high of 28.000 during the first sample period, with an average MD:AD ratio of 6.502 and the median ratio at 1.281. The coincident MD:AD ratio for the first sample period is 1.151, which is nearly identical to that of the commercial sample.

Hourly usage statistics for the industrial sample are also summarized in the table. The individual MH:AD ratios show a wide range, between 1.019 and 588.000, with an average of 105.139 and a median of 3.096. However, the calculated coincident MH:AD ratio is 1.947, which is only slightly lower than the MD:AD ratio of the residential sample during this period. This indicates that water consumption for the industrial sample is fairly consistent on a day-to-day basis during a given sample period, but may experience periodic hourly spikes during any given day.

The second sample period encompassed the period from April 6 through May 13. Twelve meters recorded usage during this period, with statistics summarized in Table 22. Combined average daily usage during this period was 35,116 units. Peak daily usage during the second period was 53,853 units, for a MD:AD ratio of 1.534, which was higher than the first period, even though the customers were generally the same. For hourly data, peak usage during this period was 63,466 units for a MH:AD ratio of 1.807, which was actually lower than the first period, in spite of the MD:AD ratio being higher.

For the third sample period, which encompasses the period from July 13 through August 12, 35 different sample meters were measured, capturing much more usage than the first two periods. Combined average daily usage during this period was 441,447 units. Peak daily usage during the second period was 557,144 units, for a MD:AD ratio of 1.262. This is more similar to the first sample than the second, even with the different mix of customers. Peak hourly usage during this period was 761,424 units, which resulted in a MH:AD ratio of 1.725, even lower than was measured for the other sample periods.

The following charts show the daily and hourly usage for the industrial class sample customers. The variation in peaking ratios could indicate several things: that the relationship between peak hour and peak day is fairly weak; that peak hour ratio increases as the total water usage in the population increases; or that industrial water usage fluctuates due to natural fluctuations in industry demand, rather than a consistent seasonal peak.

Chart 47 - Daily Industrial Water Usage by Customer and Total Sample (10/11 - 11/7)

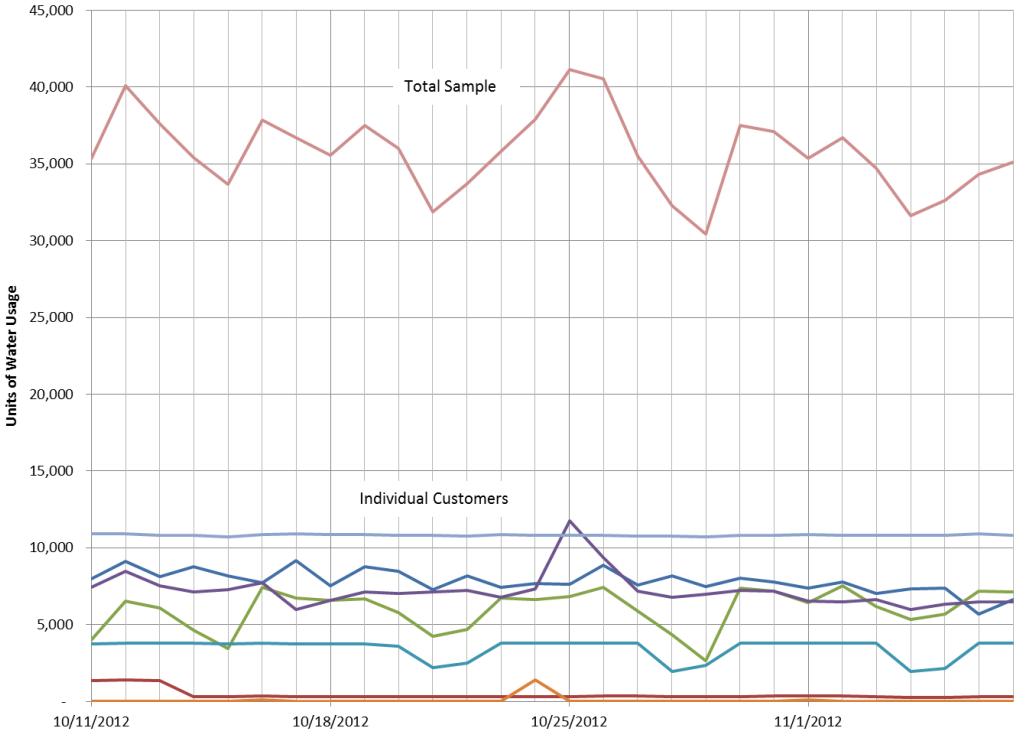


Chart 48 - Hourly Industrial Sample Usage by Day (10/11 - 11/7)

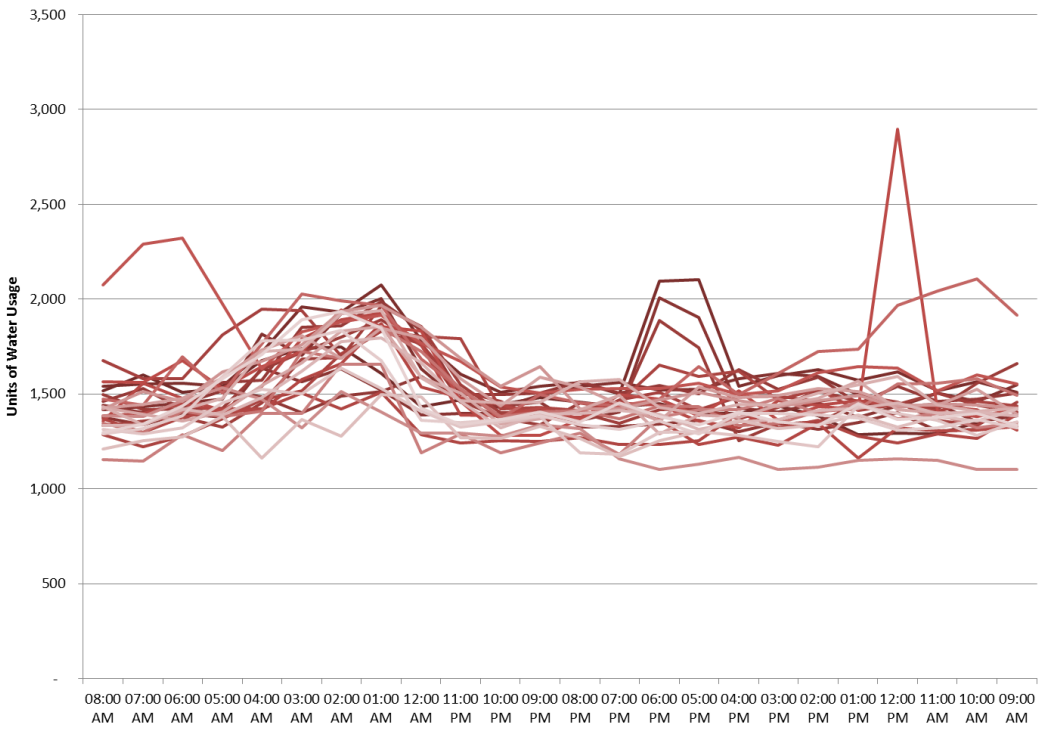


Chart 49 - Daily Industrial Water Usage by Customer and Total Sample (4/6 - 5/13)

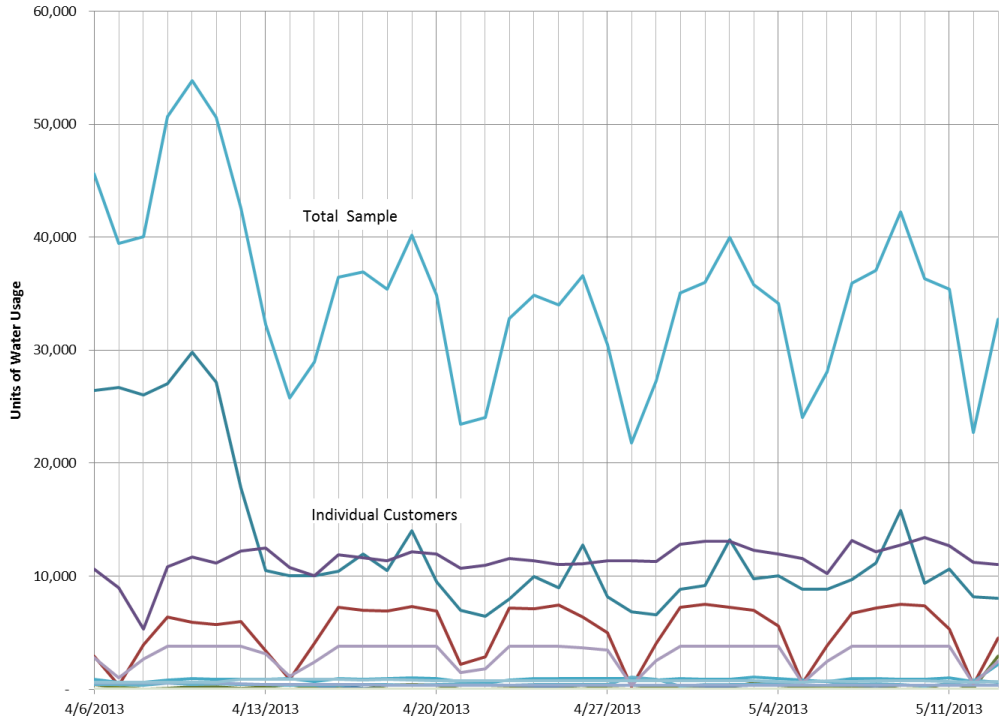


Chart 50 - Hourly Industrial Sample Usage by Day (4/6 - 5/13)

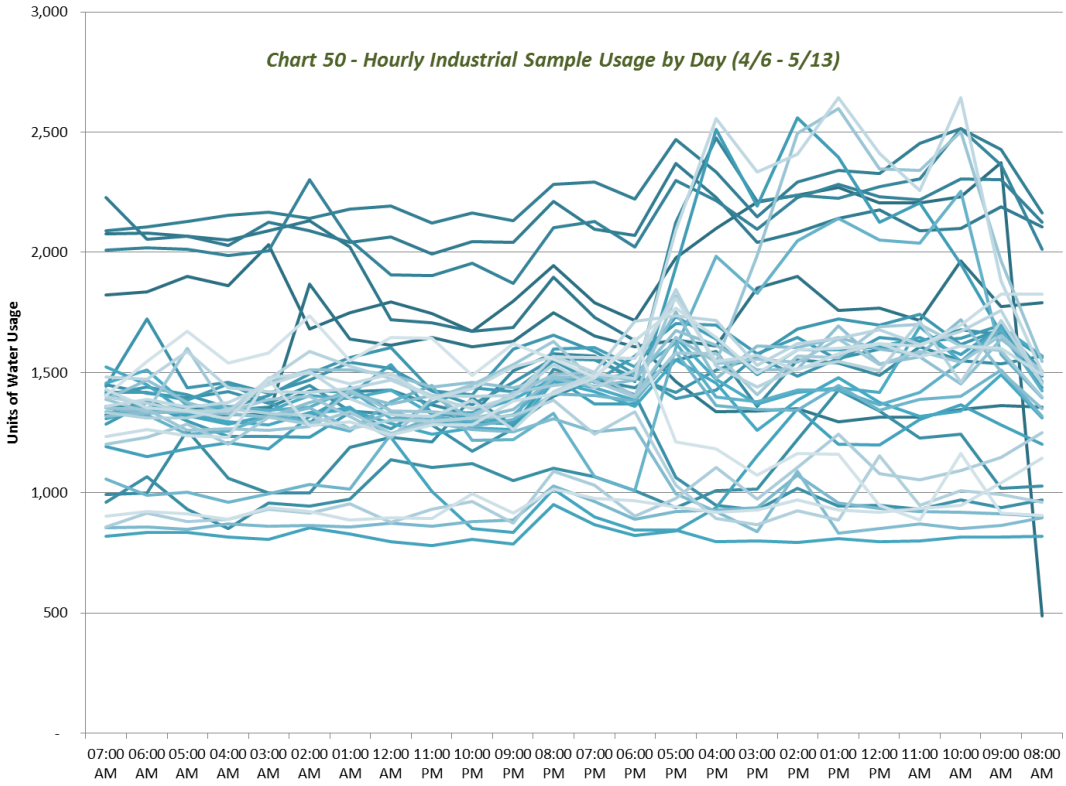


Chart 51 - Daily Industrial Water Usage by Customer and Total Sample (7/13 - 8/12)

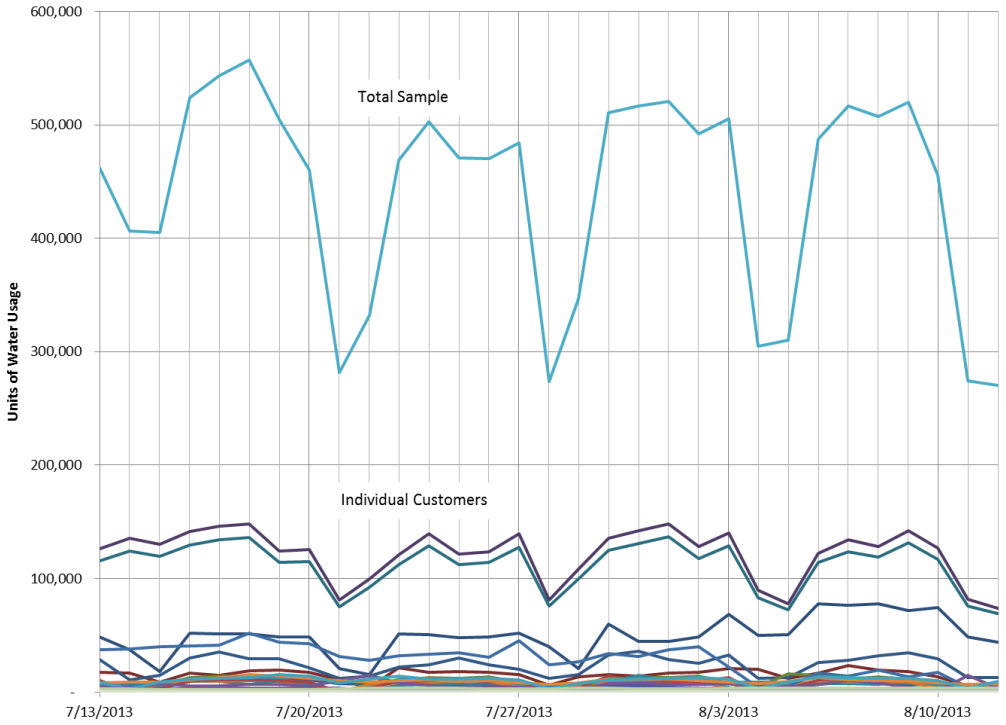
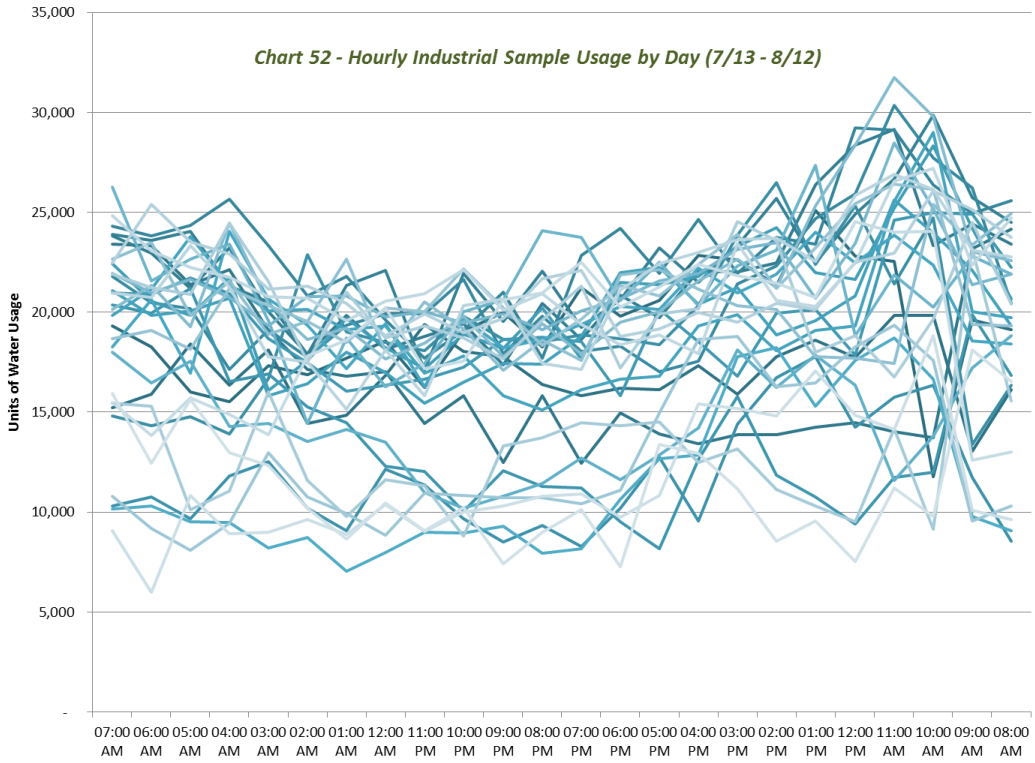


Chart 52 - Hourly Industrial Sample Usage by Day (7/13 - 8/12)



Public Authority Analysis

The first period of data that was analyzed for this class contained data for the dates of October 4 through November 5, 2012, for 18 meters, which is shown in Table 21. The range of individual MD:AD ratios shows a low of 1.157 and a high of 7.106, with average and median ratios of 2.304 and 1.684, respectively. The actual sample MD:AD ratio was 1.614. Hourly results show a strikingly higher peak ratio, with an actual coincident MH:AD ratio of 4.543.

For the analysis of public authority customers, Water Works staff were able to read eight meters during the second sample period; April 6 through May 13. The same analysis was performed and the results summarized in Table 22. The individual customers' MD:AD ratios range from a minimum of 1.192 to a maximum of 5.743, with an average ratio of 2.376 and a median of 1.931. The average daily usage of 16,344 units and the peak daily usage of 24,690 units result in a coincident MD:AD ratio of 1.511 during the second sample period, which is slightly less than the first sample period. The hourly statistical summary again shows different results for public authority meters. The peak hourly usage during the first sample period was 88,512 units, for a MH:AD ratio of 5.416, which is higher than both the first sample period and all other customer classes.

The third sample period included 26 public authority customers for the period from July 14 through August 8. The total usage and other statistics of this sample are significantly different from those of the other periods. The combined average daily usage during the second sample period was 182,399 units, with peak daily usage of 221,121 units for a MD:AD ratio of 1.212. This is lower than that of either of the other periods. Peak hourly usage during this period was 318,456 units, with a resulting MH:AD ratio of 1.746, significantly less than the other two periods by a wide margin and very similar to the industrial sample during this period.

The public authority class is comprised of customers with unique characteristics, so it is not surprising to find distinctly different demand patterns for this class as compared to the other customer classes. The following charts visually show the demand patterns for the public authority customer class sample.

Chart 53 - Daily Public Authority Water Usage by Customer and Total Sample (10/4 - 11/5)

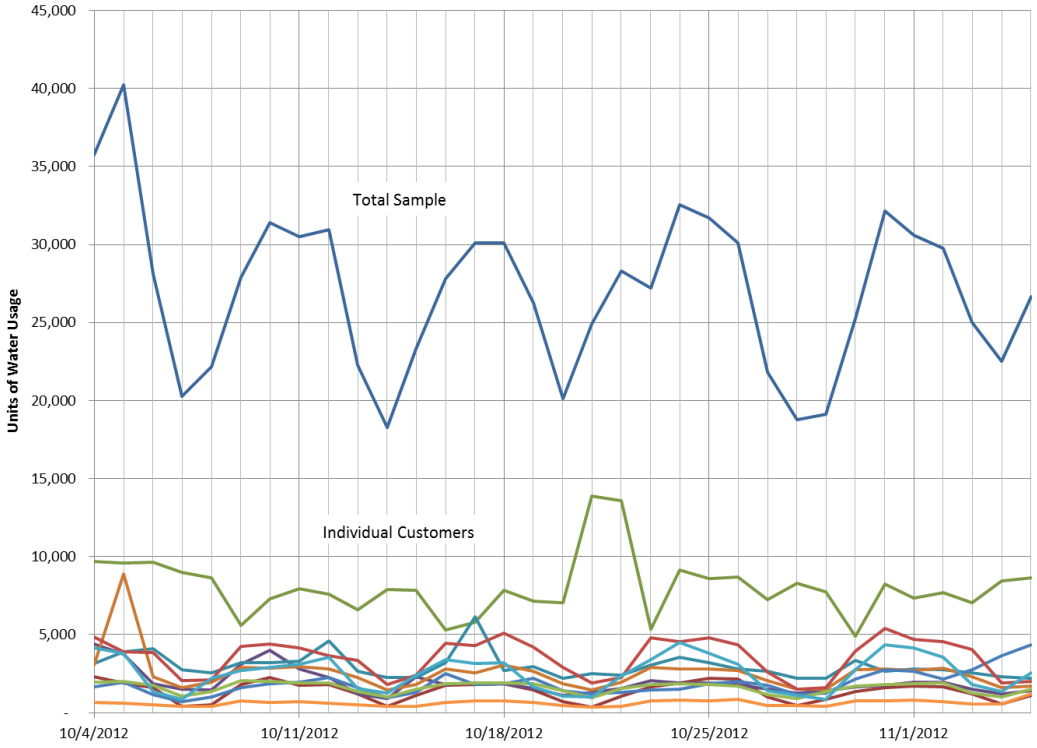


Chart 54 - Hourly Public Authority Sample Usage by Day (10/4 - 11/5)

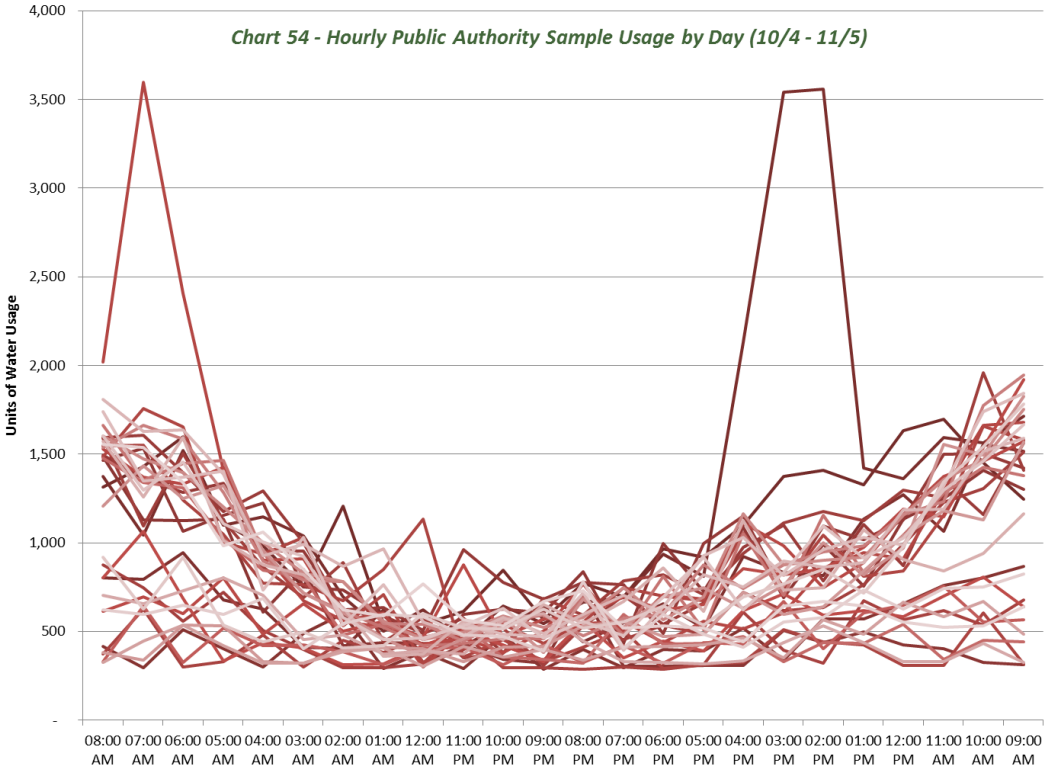


Chart 55 - Daily Public Authority Water Usage by Customer and Total Sample - (4/6 - 5/13)

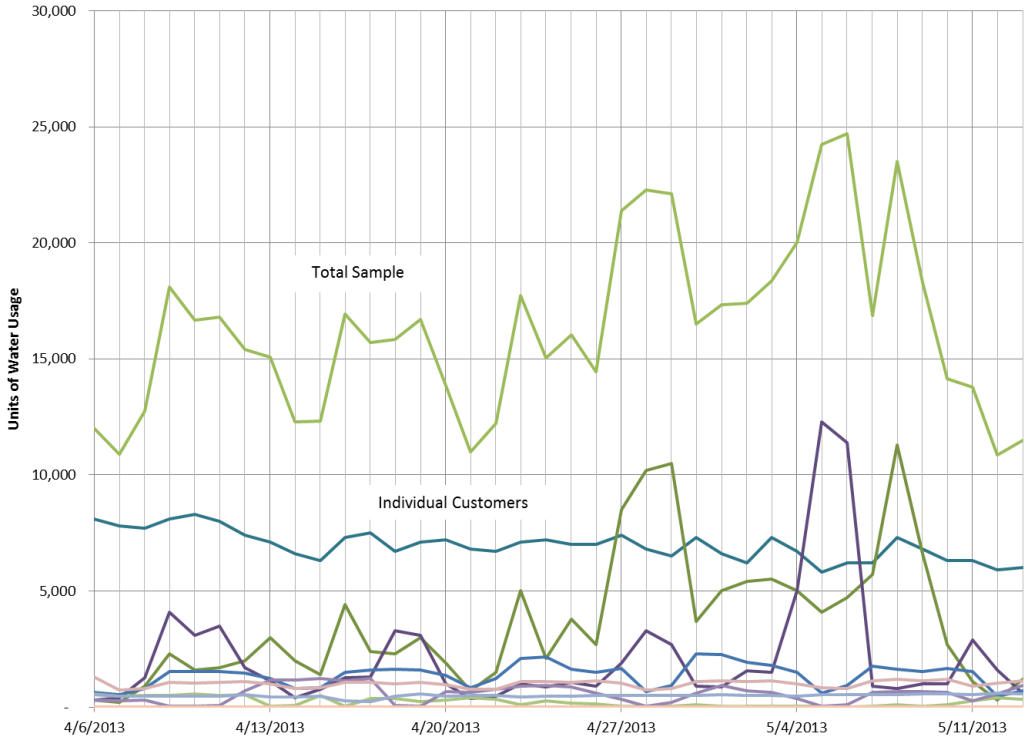


Chart 56 - Hourly Public Authority Sample Usage by Day - (4/6 - 5/13)

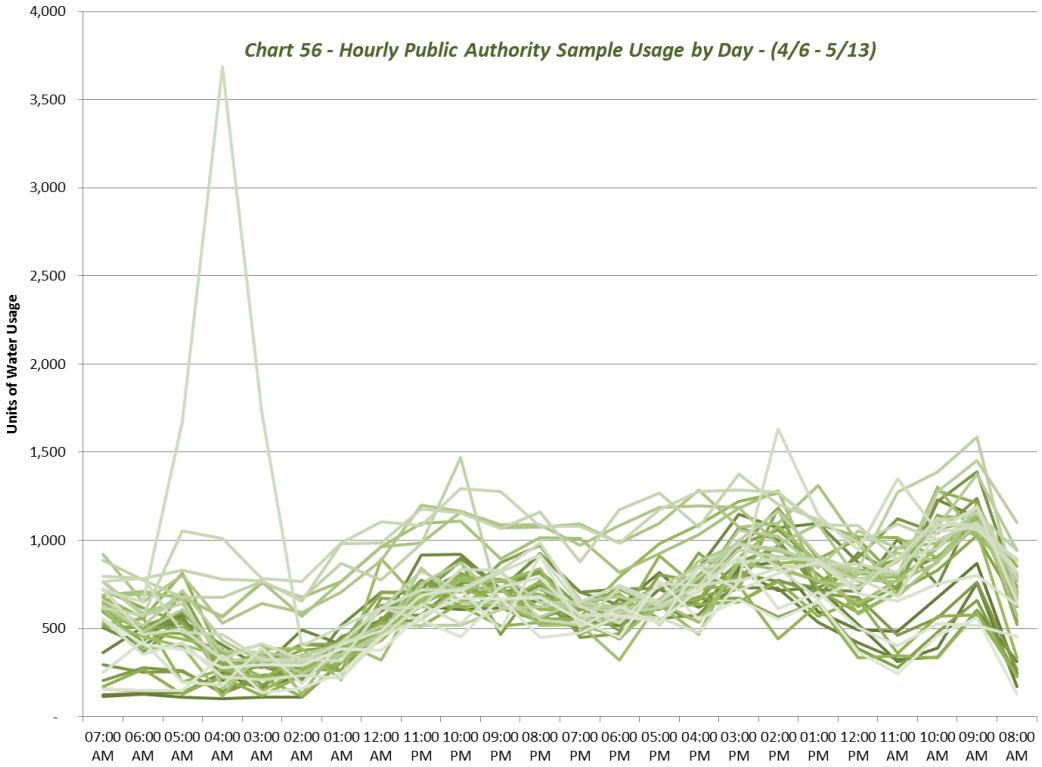


Chart 57 - Daily Public Authority Water Usage by Customer and Total Sample (7/14 - 8/8)

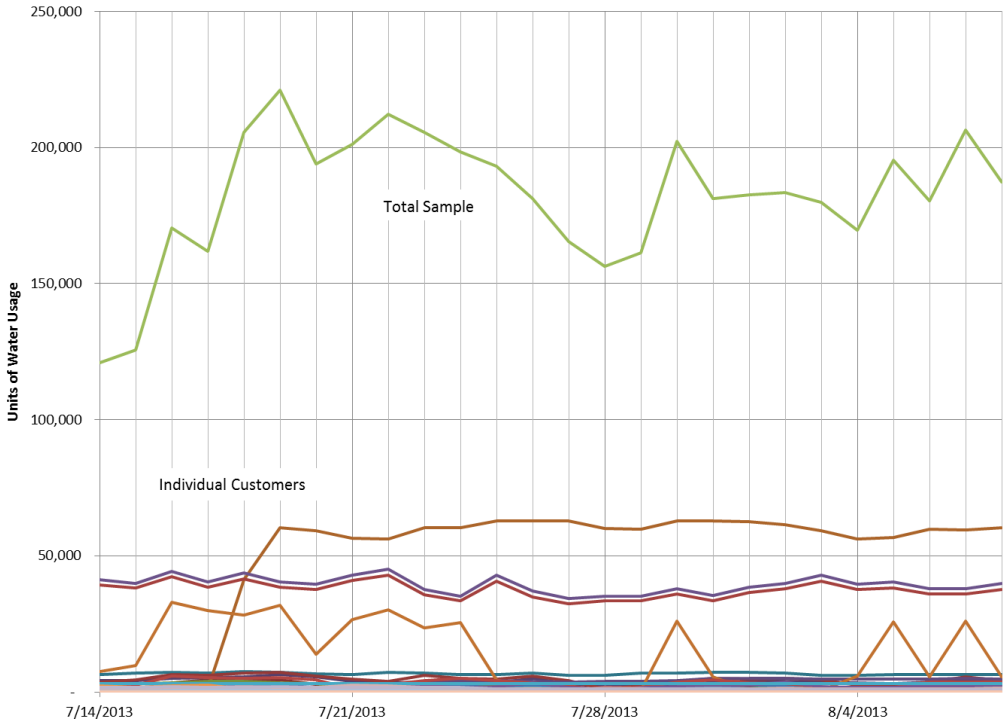
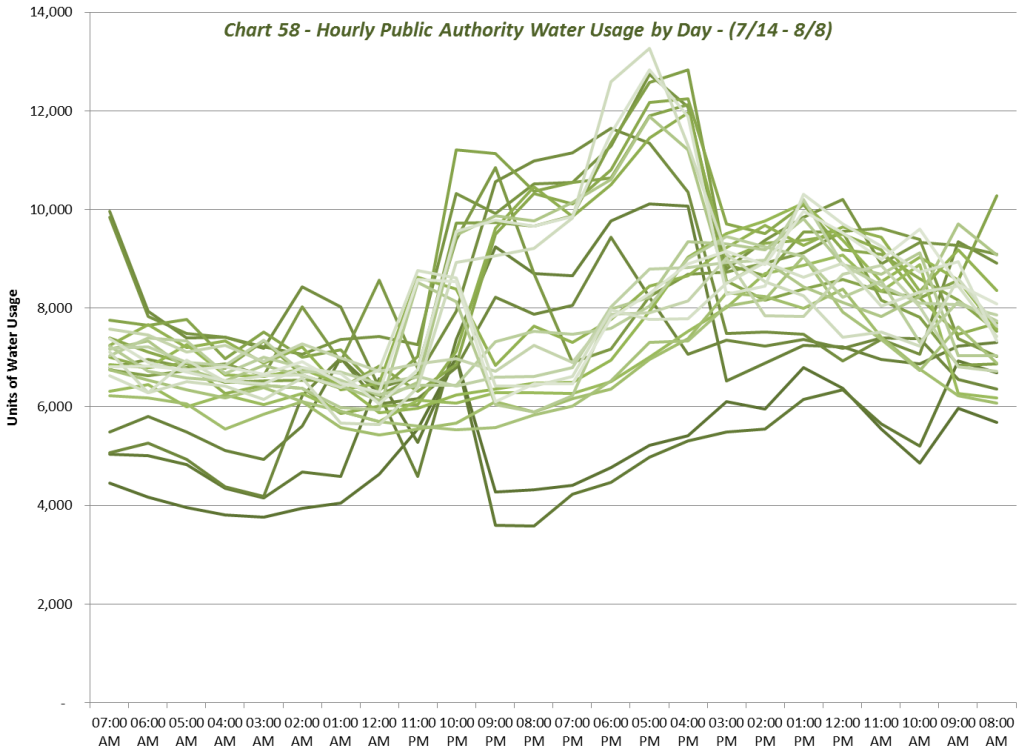


Chart 58 - Hourly Public Authority Water Usage by Day - (7/14 - 8/8)



Conclusions

Several things can be taken from the statistics of the two sample periods for 2013 and the period from 2012. Table 24 shows a comparison of the peaking ratios that were calculated during each sample period. Several observations stand out:

- Residential Sample Meters
  - The meters in the residential sample exhibit very similar peaking ratios, both daily and hourly, during the first two sample periods. However, both the MD:AD and MH:AD ratios are significantly higher during the last sample period, 7/14/13-8/8/13. As this time period occurs during the summer months, when residential customers are using water outdoors and during the time when the overall system is at its peak pumpage, it is likely that there is some cause and effect between the peak season for residential customers and higher peak ratios for usage during the peak residential usage season (month/quarter).
- Commercial Sample Meters
  - The meters in the commercial sample exhibited varied peak day and hour ratios among the three sample periods. The highest MD:AD and MH:AD ratios within a sample period occurred during April/May 2013. This period would not be expected to be a period of high monthly or quarterly usage, based on the historical analysis. Unlike residential customers, it does not appear that the peaking ratios within a specific period are higher during periods of peak seasonal use, and instead fluctuate due to other factors.
- Industrial Sample Meters
  - The peak day ratios for the industrial sample varied from period to period and were higher than those of the other classes for the period of April/May 2013. Peak hour ratios were fairly consistent and lower than those of most other customer classes. The lowest peak hour ratio occurred during summer 2013. The variation in peaking ratios within in each sample period, as well as the magnitude of the values, was somewhat surprising. However, these results could be due to the mix of customers in each sample. Each sample period included a different mix of industrial customers of varying sizes. As noted under the analysis of historical billing data, a few very large customers use most of the water for the industrial class and therefore drive the demand patterns for the class as a whole. These largest customers have very different seasonal peaking patterns from the smaller customers and may have different day-to-day and hour-to-hour usage patterns as well.
- Public Authority Meters
  - Peak day and peak hour ratios for the public authority samples were higher during the first two sample periods and lower during the summer 2013 period. The peak hour ratios were much higher during the first two periods and also much higher than those of the other customer classes. As shown on Charts 54 and 56, these extremely high peak hour ratios during fall 2012 and spring 2013 were due to one or two days with extremely high peak hours. The high peak hour ratio during spring 2013 was also driven by a single customer in the sample with a high peaking ratio and high overall usage. Thus, the ratios calculated from the sample data may be higher than the actual "typical" peaking ratios for the public authority class as a whole. However, it is not possible to

determine from the available data whether these higher ratios are anomalies or representative of the range of variation in demand by the public authority class.

- Multi-family versus other commercial meters
  - When the multi-family meters were analyzed separately from other commercial meters, additional interesting patterns emerged. First, the multi-family sample generally had lower peaking ratios than the overall commercial sample, while the sample of other commercial customers had higher ratios, particularly the MH:AD ratios. The MD:AD ratios for multi-family were similar to those of the residential class, while the MH:AD ratios were similar to those of the industrial class. The other commercial customers had peaking ratios similar to those of the public authority class.

Table 24 - Comparison of Sample Period Peak Ratios

					Commercial Meters	
	Residential Sample	Commercial Sample	Industrial Sample	Public Authority Sample	Multi-Family Sample	Non-Multi-Family Sample
Seasonal Period Dates - MD/AD Ratios						
10/11/2012 - 11/5/2012	1.191	1.160	1.151	1.614	1.230	1.464
4/7/2013 - 5/13/2013	1.179	1.448	1.534	1.511	1.162	1.726
7/14/2013 - 8/8/2013	1.403	1.342	1.262	1.212	1.323	1.564
Seasonal Period Dates - MH/AD Ratios						
10/11/2012 - 11/5/2012	2.167	2.540	1.947	4.543	1.878	5.459
4/7/2013 - 5/13/2013	2.201	2.864	1.807	5.416	1.838	4.186
7/14/2013 - 8/8/2013	2.615	2.283	1.725	1.746	2.062	3.237

ANALYSIS OF PEAKING FACTORS

Additional analysis was performed on the statistics for the sample meters with the goal of determining reasonable peaking factors to use in cost-of-service studies for the Milwaukee Water Works. Further data manipulation must be done to refine the peaking ratios resulting from the previous analysis of the sample.

The goal of this study is to determine appropriate ratios of annual maximum day and maximum hour to average day usage for each customer class. Mathematically, the ratio of the maximum day or hour usage for the year to the average day of usage for the year can be expressed using two separate ratios. The equation is as follows:

$$\frac{Maximum\ Day\ for\ Year}{Average\ Day\ for\ Year} = \frac{Maximum\ Day\ for\ Year\ (or\ Max\ Day\ during\ Max\ Period)}{Average\ Day\ during\ Maximum\ Period} \times \frac{Average\ Day\ during\ Maximum\ Period}{Average\ Day\ for\ Year}$$

The first part of the following analysis estimates the MD:AD ratio for each customer class using the equation described above. An important assumption that the analysis makes is that peak usage ratios within any given period during the year (month or quarter) are fairly constant compared to the peak ratios within any other period. Assuming this is true, the sample data can be used as the basis for the first part of the equation; that is, the MD:AD for the sample period can be used to approximate the MD:AD ratio during the Maximum Period for the year. Then, historical billing data or system pumping data can be used to estimate the ratio of the average day in the maximum month (or quarter) to the average day for the year (second part of the equation), as shown in the following simplified equation:

$$Annual\ Peaking\ Factor = Period\ Peaking\ Factor \times Seasonal\ Peaking\ Factor$$

Table 25 shows how this theory was applied to the historical and sample data to calculate customer class peaking ratios. In the table, the peaking factors within the seasonal periods (Max Day and Max Hour ratios) are taken from the previous analysis shown in Table 24. Since more than one ratio was calculated for each, the average of the three calculated ratios was used as the basis for further analysis, with the exception of the residential class, which used the highest of the three ratios. The seasonal peaks (i.e. peak quarter to average day) are taken from the analysis of the historical billing data. The commercial, industrial and public authority classes' seasonal peaking factors were based on the 7-year rolling average of peak month to average month, as shown in Table 26. The seasonal peaking factor used for the residential class is based on the overall system pumpage ratio of the average day during the max month to the average day for the year over the last two years. Because there are no data for any seasonal characteristics for peak hourly usage, the same seasonal factors as those used for the MD:AD ratio calculations were used to calculate reasonable MH:AD ratios for each customer class. This assumes that the relationship between the maximum hour usage and the maximum daily usage remains consistent throughout the year, a common assumption in determining peaking factors.

Table 25 - Calculation of Estimated Peaking Factors based on Sample and Historical Data

					Commercial Meters	
	Residential Class	Commercial Class	Industrial Class	Public Authority Class	Multi-Family Subclass	Non-Multi-Family Subclass
Peaking factor within seasonal period (Max Day)	1.40	1.32	1.32	1.45	1.24	1.58
Seasonal peak based on historical data	1.20	1.39	1.16	1.31	1.39	1.39
Estimated annual Max Day:Average Day ratio	1.68	1.84	1.53	1.89	1.73	2.21
Peaking factor within seasonal period (Max Hour)	2.61	2.56	1.83	3.90	1.93	4.29
Seasonal peak based on historical data	1.20	1.39	1.16	1.31	1.39	1.39
Estimated annual Max Hour:Average Day ratio	3.14	3.57	2.13	5.10	2.68	5.99
PSC Rate Case Demand Ratios Used - 2010						
Max Day:Average Day	2.50	2.20	1.60	2.05	2.20	2.20
Max Hour:Average Day	5.64	5.50	2.10	4.93	5.50	5.50

After performing these calculations, the resulting MD:AD peaking ratios are 1.68 for the residential class, 1.84 for the commercial class, 1.53 for the industrial class and 1.89 for the public authority class. These are mostly lower than typical ratios used by the PSC in water rate cases, as well as the MD:AD ratios used in the Milwaukee Water Works' last rate case. Those ratios were 2.50, 2.20, 1.60 and 2.05, respectively. The calculations for MH:AD peaking factors result in ratios of 3.14 for the residential class, 3.57 for the commercial class, 2.13 for the industrial class and 5.10 for the public authority class. Again, these are generally lower than the ratios used in the last rate case, which were 5.64, 5.50, 2.10 and 4.93, respectively. Additionally, the same calculations were performed for the two commercial subgroups.

Table 26 - Nonresidential Customers Average and Peak Monthly Consumption, 2007-2013

	2007	2008	2009	2010	2011	2012	2013	Average
Commercial - Monthly Billed Customers								
Peak Month	360,469	366,920	321,088	360,957	312,443	420,200	308,395	
Average Day in Peak Month	11,819	12,030	10,527	11,835	10,244	13,555	9,948	
Average Day for Year	8,674	8,616	8,119	8,221	7,745	8,270	7,636	
Average Day-Peak Month/Average Day-Year	1.363	1.396	1.297	1.440	1.323	1.639	1.303	1.394
Industrial - Monthly Billed Customers								
Peak Month	505,434	471,588	476,375	469,805	460,387	427,692	371,497	
Average Day in Peak Month	16,572	15,462	15,619	15,403	15,095	14,023	12,180	
Average Day for Year	14,289	13,600	12,827	13,137	12,556	11,915	11,225	
Average Day-Peak Month/Average Day-Year	1.160	1.137	1.218	1.172	1.202	1.177	1.085	1.164
Public Authority - Monthly Billed Customers								
Peak Month	119,507	125,797	126,108	119,153	144,007	155,490	118,425	
Average Day in Peak Month	3,918	4,124	4,135	3,907	4,722	5,098	3,883	
Average Day for Year	3,060	3,390	3,354	3,435	3,375	3,102	3,148	
Average Day-Peak Month/Average Day-Year	1.281	1.217	1.233	1.137	1.399	1.643	1.233	1.306

The results show a MD:AD ratio of 1.73 and a MH:AD ratio of 2.68 for the multi-family subclass, with a MD:AD ratio of 2.21 and a MH:AD ratio of 5.99 for the subgroup of all other commercial customers.

An alternate method to calculate MH:AD ratios is to assume that maximum hour usage is a constant multiple of the MD:AD ratio. This alternate calculation is shown in Table 27. The estimated MD:AD ratios are those calculated in Table 25. The multiples applied to the MD:AD ratios are averages calculated from the statistical summary in Table 24. This results in similar, yet slightly different MH:AD ratios: 3.11 for the residential class, 3.59 for the commercial class, 2.16 for the industrial class and 4.93 for the public authority class.

Table 27 - Calculation of Estimated Hourly Peaking Factors based on Multiples of Daily Peaking Factors

					Commercial Meters	
	Residential Class	Commercial Class	Industrial Class	Public Authority Class	Multi-Family Subclass	Non-Multi-Family Subclass
Peaking factor within seasonal period (Max Day)	1.68	1.84	1.53	1.89	1.73	2.21
Class multiple of max day based on sample data	1.85	1.96	1.41	2.61	1.56	2.74
Estimated annual Max Hour:Average Day ratio	3.11	3.59	2.16	4.93	2.69	6.06
Mathematically the same if consistent factors are used between max day and max hour.						
PSC Rate Case Demand Ratios Used - 2010						
Max Day:Average Day	2.50	2.20	1.60	2.05	2.20	2.20
Max Hour:Average Day	5.64	5.50	2.10	4.93	5.50	5.50

The analysis also tested for the reasonableness of the preliminary recommended peaking factors by calculating composite MD:AD and MH:AD ratios for all customer classes, then comparing the composite ratios to the actual system ratios. A similar calculation is also done in PSC cost-of-service studies, known as the ratio of the non-coincident peak usage for all customer classes to coincident system peak usage (or system diversity). The analysis calculated the composite ratios in two ways: weighted by proportionate total usage; and weighted by proportionate peak usage.

The calculated new peaking factors were applied to the average day consumption figures used in the previous rate case and compared to system peaking factors used in that rate case, as shown in Tables 28 and 29. When this is done, the composite ratios are much closer to the actual system peaks; that is, much lower than the composite ratios used in the last cost-of-service study. The MD:AD composite ratio is 20-21 percent higher than the actual system peak day ratio, with the MH:AD composite ratio 89-95 percent higher than the estimated system peak hour ratio, depending on the weighting factor used. This seems to indicate that peaking factors calculated with the sample data are reasonable.

Table 28 - Comparison of Composite Peaking Factors with Actual System Peak Usage, Weighted by Average Usage

	Residential Class	Commercial Class	Industrial Class	Public Authority Class	Composite	% Difference	Actual
2010 Rate Case:							
Max Day:Average Day used	2.50	2.20	1.60	2.05	2.23	56%	1.43
Max Hour:Average Day used	5.64	5.50	2.10	4.93	4.97	188%	1.73
% of class annual consumption	45%	32%	16%	8%			
(excludes wholesale from class % calculation)							
Applying new factors to rate case consumption:							
Max Day:Average Day	1.68	1.84	1.53	1.89	1.72	20%	1.43
Max Hour:Average Day	3.14	3.59	2.16	5.10	3.27	89%	1.73

Table 29 - Comparison of Composite Peaking Factors with Actual System Peak Usage, Weighted by Peak Usage

	Residential Class	Commercial Class	Industrial Class	Public Authority Class	Composite	% Difference	Actual
2010 Rate Case:							
Max Day:Average Day used	2.50	2.20	1.60	2.05	2.27	59%	1.43
Max Hour:Average Day used	5.64	5.50	2.10	4.93	5.30	206%	1.73
% of non-coinc. max day consumption	50%	31%	12%	7%			
% of non-coinc. max hour consumption	51%	35%	7%	8%			
(excludes wholesale from class % calculation)							
Applying new factors to rate case consumption:							
Max Day:Average Day	1.68	1.84	1.53	1.89	1.73	21%	1.43
Max Hour:Average Day	3.14	3.59	2.16	5.10	3.38	95%	1.73

RECOMMENDATIONS AND CONCLUSIONS

This study's purpose was to recommend appropriate and reasonable peaking factors for use in Milwaukee's upcoming rate cases. To this end, several conclusions can be drawn.

One important conclusion is that the analysis confirms that most of the max day and max hour peaking factors used for Milwaukee's retail customers in the last rate case were higher than warranted based on the actual patterns of peak consumption. The measured ratios of max day and max hour usage to average day usage for all customer classes during the sample periods were much lower than the ratios used in the last rate case. Even when these ratios were adjusted for seasonal fluctuation, the resulting ratios were still much lower than the ratios used in the last rate case.

Additional testing and analysis of the calculated ratios confirmed that these lower ratios are more reasonable than the ratios used in the last rate case. The calculated composite max day and max hour ratios of all of the customer classes in the sample (applying the peak ratios for each class to the proportion of average day usage) was somewhat higher than the actual max day and max hour of the entire system. However, the ratios used in the last rate case, after being applied to the proportion of average day water usage from the last rate case, yielded composite max day and max hour ratios that were much higher than the actual system peaks.

The data obtained for this study was different than what was envisioned in the study design in terms of the number of customers sampled and the time period during which the sample data was obtained. First, the sample size for each class was smaller than intended, which likely, but not certainly, resulted in measured peak ratios for the sample that are somewhat higher than the actual peaks for the entire customer class during the same period. However, this study confirmed that there is no correlation between the average or standard deviation of the peak ratios of individual customers and the coincident peak of the group. The data for all customer class samples demonstrated a strong "muting" effect – the peak ratios of the total sample group were much lower than the average peak ratios of the individual customers within each class. This occurs because the max day and max hour usage for individual customers occur at different times. It is logical that this muting effect increases as more customers are included in the group. Therefore, with a smaller sample size, the observed peak ratios of the class as a whole generally would be expected to be higher than for a larger sample size.

Between 2012 and 2013, the study recommended the following courses of action as a part of this study:

- The sample sizes for each class should be increased to include as many of the customers on the original sample list as possible.
    - *This was done to the extent possible.*
- The time period for which data is gathered should be expanded to include May through November.
    - *This was also done to the extent possible; the two sample periods include data from April/May and July/August, in addition to data from October/November 2012.*
- The units measured by the ERTs should also be reconciled with the units used for billed consumption, so that the max day and max hour for each customer can be compared to the average day consumption for the entire year.
    - *Average day consumption for the entire year was not used as part of the analysis; however the units measured by the ERTs for each meter in each customer class were reviewed and some of the data was adjusted as needed so that all of the data for each customer class was in the same units.*
- Hourly pumpage rates for wholesale customers should continue to be gathered and analyzed as they become available in order to determine if this data can be used to calculate max day and max hour ratios for these customers.
    - *This data was gathered for eight of the 10 wholesale customers and analyzed to determine appropriate peaking factors for these customers, as explained in that section of the report.*

Based on these observations, it is recommended that the utility establish wholesale and retail customer class max day and max hour ratios in the next rate case and cost-of-service study that reflect the results of this study. Based on the available data, a conservative approach to recommending new peaking factors was taken; therefore, recommended peaking factors were established by rounding up from the calculated ratios from Tables 25 and 27. Residential peaking ratios were rounded up to the nearest half-point, commercial and public authority ratios were rounded up to the nearest quarter-point and industrial peaking ratios were rounded up to the nearest tenth-point. The residential class was given a greater margin because there is less available information on the seasonal peaking ratio for the residential class, and system seasonal factors were used instead. The industrial class was given a smaller margin because the sample contained a larger

percentage of total class usage than the other classes and adding additional customers to the sample would likely have little impact to the calculated peak ratios. Therefore, based on the available data, the recommended ratios are as shown in Table 30.

Table 30 - Recommended Peaking Factors for Cost-of-Service Study

	Residential Class	Commercial Class	Industrial Class	Public Authority Class
Maximum Day : Average Day Peak Ratio	2.00	2.00	1.60	2.00
Maximum Day Extra Capacity Factor	1.00	1.00	0.60	1.00
Maximum Hour : Average Day Peak Ratio	3.50	3.75	2.20	5.25
Maximum Hour Extra Capacity Factor	2.50	2.75	1.20	4.25